U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-255 251

REGIONAL WATER QUALITY-QUANTITY SYSTEMS ANALYSIS

LARIMER-WELD REGIONAL PLANNING COMMISSION

JUNE 1971

BIBLIOGRAPHIC DATA SHEET	1. Report No.	2.	3. Recipient's Accession No. PB-255 251
4. Title and Subtitle Regional Water Quality-Quantity Systems Analysis.			5. Report Date June 1971 6.
7. Author(s) William C. Manuel, David W. Hendricks, and H. J. Morel-Seytoux.			8. Performing Organization Rept. No.
9. Performing Organization Name and Address Larimer-Weld Regional Planning Commission Fort Collins, Colorado			10. Project/Task/Work Unit No. 11. Contract/Grant No.
12. Sponsoring Organization Name and Address			13. Type of Report & Period Covered 14.

15. Supplementary Notes

Prepared in cooperation with Colorado State University, Fort Collins.

16. Abstracts

The project objective is to develop and demonstrate a pragmatic methodology for total planning of an ingegrated water supply-liquid waste handling system on a regional scale (county wide and larger). This will require defining the location, the size and time phasing of each treatment plant in a regional array. Existing and additional primary and secondary plants are considered along with tertiary plants, desalting, and dilution in assessing incremental improvements in water quality versus incremental costs. Both treatment costs and the costs of water transport are considered as a function of scale. The objective is to meet the projected diversion demand requirements and the quality requirements for in-stream water quality and for each utilitarian use within the system.

17. Key Words and Document Analysis. 17a. Descriptors

*Water resources
*Water supply
*Water pollution
*Regional planning
Project planning
Sewage treatment
Industrial waste treatment
Financing
Optimization
Systems analysis
Ground water
Agriculture
Linear programming
Demand(Economics)
Cost analysis
Water Distribution
Stream flow
Colorado

17b. Identifiers/Open-Ended Terms

*Water demand
Larimer County(Colorado)
Weld County(Colorado)

17c. COSATI Field/Group 13B

18. Availability Statement
National Technical Information Service
Springfield, VA 22161

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PB 255 251

210086

"REGIONAL WATER QUALITY-QUANTITY SYSTEMS ANALYSIS"

Proposal

to

Environmental Protection Agency

From

Larimer-Weld Regional Planning Commission

by

William C. Manuel
Larimer County Commissioner

David W. Hendricks
Associate Professor of Civil Engineering
Colorado State University

H. J. Morel-Seytoux
Associate Professor of Civil Engineering
Colorado State University

June 1971

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SPRINGFIELD, VA. 22161

larimer-weld regional planning commission

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Denver, Colorado

June 9, 1971

Environmental Protection Agency
Water Quality Office
Washington, D. C.

ATTN: Dr. Roger Don Shull
Environmental Engineering
Pollution Control Analysis Branch
Division of Applied Science and Technology
Environmental Protection Agency
Washington, D. C. 20242

Dear Sirs:

Enclosed please find ten copies of a demonstration grant application entitled, "Regional Water Quality-Quantity Systems Analysis."

We shall be happy to provide any supplemental information to assist in your review process, as necessary.

Sincerely,

William C. Manuel
Larimer County Commissioner

D W Hendricks
by HJM

David W. Hendricks
Associate Professor of Civil Engineering

Hubert J. Morel-Seytoux
Associate Professor of Civil Engineering

cc: Mr. Frank Rozich
Mr. P. Godsil
Mr. D. Clark
Dr. N. Evans

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U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
WASHINGTON, D. C. 20242

APPLICATION FOR RESEARCH, DEVELOPMENT, AND DEMONSTRATION GRANT

FWPCA USE ONLY
PROGRAM NO.
ACCOUNT NO.
DATE RECEIVED:

PART I, SECTION A, REQUEST AND CERTIFICATION

1. TYPE OF GRANT
[ ] CLASS I - RESEARCH [X] CLASS II - DEMONSTRATION [ ] CLASS III - STORM & COMBINED SEWER [ ] CLASS IV - ADVANCED WASTE TREATMENT [ ] CLASS V - INDUSTRIAL WASTE

2. TITLE OF PROJECT
Regional Water Quality-Quantity-Systems Analysis

3. APPLYING ORGANIZATION AND MAILING ADDRESS (ZIP Code)
Larimer-Weld Regional Planning Commission
P.O. Box 2137
Fort Collins, Colorado 80521

4. PROJECT LOCATION AND MAILING ADDRESS (ZIP Code)
Larimer County Courthouse, P.O. Box 2137
Fort Collins, Colorado 80521, and
Engineering Research Center, Colorado State University
Fort Collins, Colorado 80521

5. GRANT DIRECTOR: MAILING ADDRESS (ZIP Code) AND TELEPHONE NO.
William C. Manuel, Larimer County Commissioner
P.O. Box 2137
Fort Collins, Colorado 80521

303-484-1303

6. PROJECT DIRECTOR: MAILING ADDRESS (ZIP Code) AND TELEPHONE NO.
David W. Hendricks
Hubert J. Morel-Seytoux
Engineering Research Center, CSU
Fort Collins, Colorado 80521

7. FINANCIAL OFFICER (To Receive Grant Funds), MAILING ADDRESS (ZIP Code) AND TELEPHONE NO.
William C. Manuel
P.O. Box 2137
Fort Collins, Colorado 80521
303-484-1303

8. TYPE OF APPLICATION ("X" appropriate box)

X	NEW	
	REVISION (TO):	FWPCA GRANT NO:
	CONTINUATION (OF):	

9. PROJECT FINANCING

a. FOR TOTAL PROJECT:

TOTAL PROJECT PERIOD:	(FROM) 9/1/71	(THROUGH) 8/31/74
TOTAL PROJECT COST:	$600,000 (est.)	

b. FOR THIS REQUEST: $206,039

GRANT PERIOD:	(FROM) 9/1/71	(THROUGH) 8/31/72
APPLICANT'S SHARE:	$ 51,656	
GRANT REQUESTED:	$154,383	
TOTAL:	$206,039	

FWPCA USE ONLY

APPROVED PROJECT PERIOD	
FROM	THROUGH

APPROVED ESTIMATED PROJECT COST	
APPLICANT'S SHARE	$
GRANT REQUESTED	$
TOTAL	$

10. TERMS AND CONDITIONS

The attached statements and exhibits are hereby made part of this application and the undersigned representative of the Applicant certifies that the information in the application and in the attached statements and exhibits is true, correct, and complete to the best of his knowledge and belief. He further certifies that: He has been authorized to file this application by formal action of the governing body of the Applicant as is evidenced by the ATTACHED CERTIFIED COPY OF AUTHORIZATION MADE BY THE APPLICANT'S GOVERNING BODY; the governing body of the Applicant agrees that if a Federal grant for the Project is made on the basis of this application or on the basis of any provision or amendment thereof, it will comply with all of the applicable requirements and conditions of the regulations governing grants for water pollution control authorized by the Water Pollution Control Act, as amended (33 U.S.C. 466 et. seq.) and with such additional conditions as the Commissioner may impose prior to or at the time of the grant award.

SIGNATURE OF PERSON AUTHORIZED TO SIGN: Dwight [illegible]
TITLE:
DATE: 6-9-71

FORM APPROVED
BUDGET BUREAU NO. 42-R1562

GIVE A BRIEF DESCRIPTION OF THE PROJECT, SUMMARIZING THE PROJECT OBJECTIVES AND PLAN OF OPERATION DESCRIBED IN THE DETAILED PROJECT PLAN (PART II, SECTION A). *(Limit the summary to the space provided)*

The project objective is to develop and demonstrate a pragmatic methodology for total planning of an ingegrated water supply-liquid waste handling system on a regional scale (county wide and larger). This will require defining the location, the size and time phasing of each treatment plant in a regional array. Existing and additional primary and secondary plants are considered along with tertiary plants, desalting, and dilution in assessing incremental improvements in water quality versus incremental costs. Both treatment costs and the costs of water transport are considered as a function of scale. The objective is to meet the projected diversion demand requirements and the quality requirements for in-stream water quality and for each utilitarian use within the system. Water reuse is implied, if necessary, by the statement of the problem.

The essential core of the methodology is a planning matrix. This matrix consists of all categories of inputs seen as rows, such as base stream flow, ground water, a stream reach, a diversion, a treatment plant effluent, agricultural return flow, etc. The destinations of these inputs consist of a water treatment plant, an irrigation diversion, a waste treatment plant, or another stream reach. Thus the matrix can display any relationship desired between input vectors (e.g. a row in the matrix) and each destination category. Examples of entries in the matrix include:

1) the effect caused (i.e. quality degradation caused by use)
2) the effect needed (i.e. quality improvement needed for a given use)
3) the quantities needed for each use
4) the benefits resulting from 1) and 5) the costs for 2) and 3)

Optimization can be in terms of maximizing net benefits or minimizing costs with the constraints of the system. We will use the least cost objective function - since many benefits cannot be assigned dollar value. Where necessary to assess intangible benefits we will use the opportunity cost approach.

The planning methodology to be developed by this project will have a special orientation, namely to provide an integrated regional approach to basin planning. It should provide the capability for assessing the effect of any one activity within a basin, on all other activities.

The results of the demonstration will provide a feasible tangible system plan for the demonstration project area (South Platte, Poudre and Big Thompson River basins within the Larimer and Weld Counties). This area has a semi-arid character, a limited water supply, and is experiencing a fast rate of growth.

In fact the results of the study will satisfy the requirements for a certified basin and regional/metropolitan (Fort Collins, Loveland, Greeley triangle) plan as specified in the EPA Guidelines for Water Quality Management Planning dated January 1971. Clearly the study will be of immediate value to the Larimer-Weld region for development of a certified plan by July 1, 1973. However, the value of the study to the Larimer-Weld region is incidental (though significant) in the sense that a major goal of the project is to pursue the demonstration in such a way that the approach and the planning algorithm will be transferable to system planning in other regions. In fact adoption of the methodology and algorithms developed in the study and demonstrated on the Larimer-Weld region should facilitate the task of the planning agencies to submit plans in full accordance with the EPA Guidelines.

PART I, SECTION C, APPROVAL BY STATE WATER POLLUTION CONTROL AGENCY *(If applicable)*

TITLE OF PROJECT

Regional Water Quality-Quanity Systems Analysis

GRANT APPLICANT

Larimer-Weld Regional Planning Commission

The project described above, if carried out in accordance with the proposed plan of operation, is hereby approved.

NAME OF OFFICIAL STATE WATER POLLUTION CONTROL AGENCY

Colorado Water Pollution Control Commission

SIGNATURE OF RESPONSIBLE OFFICER	TITLE OF OFFICER	DATE
Frank Rozich	Tech. Sec., W.P.C.C.	6/8/71

PART I, SECTION D-1, FINANCIAL SUMMARY

1. ESTIMATED PROJECT COSTS DURING GRANT PERIOD

	ITEM	PROPOSED BY APPLICANT		FWPCA USE ONLY	
		TOTAL FOR GRANT PERIOD	GRANT REQUESTED	ELIGIBLE COSTS	FWPCA OFFER
RESEARCH/DEVELOPMENT/DEMONSTRATION STUDIES	A. SALARIES AND WAGES	114,703	80,600		
	B. FRINGE BENEFITS	6,806	4,012		
	C. CONSULTANT SERVICES				
	D. EQUIPMENT	5,400	5,400		
	E. SUPPLIES	3,500	3,500		
	F. TRAVEL	1,950	1,950		
	G. PUBLICATION COSTS	1,000	1,000		
	H. OTHER	8,000	8,000		
	I. CONTRACTS				
	TOTAL DIRECT COSTS (A thru I)		104,462		
	J. INDIRECT COSTS 40%LWRPC 14,759 59%CSU 49,921	64,680	49,921		
	TOTAL R/D/D STUDIES (A thru J)	206,039	154,383		
FACILITIES	K. CONSTRUCTION-ENGINEERING PLANS				
	L. CONSTRUCTION - SUPERVISION				
	M. CONSTRUCTION - CONTRACTS				
	N. CONSTRUCTION - MATERIALS				
	TOTAL CONSTRUCTION (K thru N)				
	O. OPERATION - SALARIES & WAGES				
	P. OPERATION - FRINGE BENEFITS				
	Q. OPERATION - SUPPLIES				
	R. OPERATION - UTILITIES				
	S. OPERATION - REPAIRS				
	TOTAL OPERATION (O thru S)				
	TOTAL FACILITIES (K thru S)	206,039	154,383		
	TOTAL PROJECT COSTS (A thru S)				

PART I, SECTION D-1, FINANCIAL SUMMARY (Continued)

2. PROPOSED FUNDING

ITEM	PROPOSED BY APPLICANT		FWPCA USE ONLY	
	PERCENT	FUNDS	PERCENT	FUNDS
A. APPLICANT'S SHARE	25	$ 51,656		$
B. GRANT REQUESTED	75	154,383		
C. TOTAL	100	$ 206,039	100	$

3. SUPPORT TO BE USED FOR THE PROJECT

ITEM	DATE AVAILABLE	AMOUNT
A. CASH		$
B. GENERAL OBLIGATION BONDS		
C. REVENUE BONDS OR CERTIFICATES		
D. OTHER (Specify) In Kind Services	Sept. 1, 1971	51,656
E. ANTICIPATED FWPCA GRANT		154,383
F. TOTAL		$ 206,039

REMARKS

Further matching commitments from other political entities in the two counties can be made available if needed; some verbal commitments have been made by several municipalities but since they have not yet been formalized in writing, therefore they have not been included in the budget.

The 40% overhead rate for the LWRPC is provisional; no official rate has been established for this body.

PART I, SECTION D-2, FINANCIAL DETAIL - RESEARCH/DEVELOPMENT/DEMONSTRATION STUDIES

A. Salaries and Wages

NAME	POSITION	PROFESSION OR SKILL	ANNUAL SALARY	TIME ON PROJECT (% or hrs)	COST
William C. Manuel	Larimer County Commissioner	Administration Programming	10,000	20%	$
Douglas Wigle	Director, Larimer County Health Department	Sanitarian	15,000	30%	4,500
Dwight Whitney	Larimer County Planner	Planning	13,800	10%	1,380
2	Technicians	Field Sampling	8,244	75%	12,036
2	Technicians	Laboratory Analysis	6,000	70%	8,400
				TOTAL A	$ 26,316

B. Fringe Benefits

NAME	TYPES OF BENEFITS (Social Security, Group Life Insurance, Retirement, etc.)	
	8.2%	$
Douglas Wigle		369
Dwight Whitney		113
2 Technicians		986
2 Technicians		688
	TOTAL B	$ 2,156

C. Consultant Services

CONSULTANT (If known)	SERVICES TO BE PERFORMED	
		$
	TOTAL C	$

D. Equipment

ITEM	HOW OBTAINED (purchase, rental, furnished by applicant)	
BOD Incubator	purchase	$ 600
Electrical conductivity bridge	purchase	600
	TOTAL D	$ 1,200

E. Supplies

ITEM	HOW OBTAINED (as in D. above)	QUANTITY	UNIT COST	
Laboratory glassware (BOD bottles pipettes, burrettes, etc)	purchase			$ 1,500
			TOTAL E	$ 1,500

PART I, SECTION D-2, FINANCIAL DETAIL - RESEARCH/DEVELOPMENT/DEMONSTRATION STUDIES

A. Salaries and Wages

NAME	POSITION	PROFESSION OR SKILL	ANNUAL SALARY	TIME ON PROJECT (% or hrs)	COST
Burman Lorensen	Weld County Planner	Planning	14,500	10%	$ 1,450
Glenn Paul	Chief Sanitarian Weld County Health Department	Sanitarian	12,000	10%	1,200
Byron Ewing	County Engineer	Engineering	10,000	5%	500
	Sanitary Technician		6,183	75%	4,637
				TOTAL A	$ 7,787

B. Fringe Benefits

NAME	TYPES OF BENEFITS (Social Security, Group Life Insurance, Retirement, etc.)	
Burman Lorensen	8.2%	$ 119
Glenn Paul		98
Byron Ewing		41
Technician		380
	TOTAL B	$ 638

C. Consultant Services

CONSULTANT (If known)	SERVICES TO BE PERFORMED	
		$
	TOTAL C	$

D. Equipment

ITEM	HOW OBTAINED (purchase, rental, furnished by applicant)	
		$
	TOTAL D	$

E. Supplies

ITEM	HOW OBTAINED (as in D. above)	QUANTITY	UNIT COST	
				$
			TOTAL E	$

PART I, SECTION D-2, FINANCIAL DETAIL - RESEARCH/DEVELOPMENT/DEMONSTRATION STUDIES

A. Salaries and Wages

NAME	POSITION	PROFESSION OR SKILL	ANNUAL SALARY	TIME ON PROJECT (%, or hrs.)	COST
David W. Hendricks	Assoc. Prof. of Civil Engr.	San. Eng. Sys. Anal.	25,740	50%	$ 12,870
Hubert J. Morel-Seytoux	Assoc. Prof. of Civil Engr.	Hydrol. Op. Res.	24,192	50%	12,096
1	Economist	Economics	24,000	16.7%	4,000
6	Grad. Res. Assistants		7.860	62%	29,250
	Admin. Assist-Secretary		6,204	100%	6,204
	Professional Programmer		9,600	100%	9,600
	Keypunch Operator		4,860	50%	2,430
3	Undergraduate Students		12,575	33⅓	4,150
				TOTAL A	$ 80,600

B. Fringe Benefits

NAME	TYPES OF BENEFITS (Social Security, Group Life Insurance, Retirement, etc.)	
David W. Hendricks	PERA 8 1/2 %	$ 1,094
Hubert J. Morel-Seytoux	PERA 8 1/2 %	1,028
Economist	PERA 8 1/2 %	340
Adm. Asst.	PERA 8 1/2 %	527
Programmer	PERA 8 1/2 %	816
Keypunch Op.	PERA 8 1/2 %	207
		TOTAL B $ 4,012

C. Consultant Services

CONSULTANT (if known)	SERVICES TO BE PERFORMED	
		$
		TOTAL C $

D. Equipment

ITEM	HOW OBTAINED (purchase, rental, furnished by applicant)	
IBM Card Files (2)	Purchase	$ 700
Electronic Calculator	Purchase	2,400
Desk Calculator	Purchase	600
Time/Data 100	Purchase (jointly with several other projects)	500
		TOTAL D $ 4,200

E. Supplies

ITEM	HOW OBTAINED (as in D. above)	QUANTITY	UNIT COST	
Office Supplies				$ 2,000
Computer Cards and Tapes				
Microfilms				
Microfilm prints				
Xeroxing, etc.				
				TOTAL E $ 2,000

PART I, SECTION D-2, FINANCIAL DETAIL - RESEARCH/DEVELOPMENT/DEMONSTRATION STUDIES (Cont.)

F. Travel

TRAVELER	DESTINATION AND PURPOSE	NO. OF TRIPS	COST PER TRIP	COST
D. W. Hendricks	Professional meetings related to project	2	300	$ 600
H. J. Morel-Seytoux		2	300	600
D. W. Hendricks H. J. Morel-Seytoux Graduate Research Assistants	Local trips within the project area for information, data collection, consultation with local authorities	50	15	715
			TOTAL F	$ 1,950

G. Publication Costs

ITEM	PURPOSE	
Quarterly Progress Reports Annual Reports, Publications	To report project progress and collate significant findings	$ 1,000
	TOTAL G	$ 1,000

H. Other

ITEM	PURPOSE	
CDC 6400	for developing regional models	
CP @ 315/hr		5,000
PP @ 65/hr		3,000
	TOTAL H	$ 8,000

I. Contracts

LIST ANTICIPATED CONTRACTS BY PURPOSE, PROBABLE CONTRACTOR IF KNOWN, AND ESTIMATED COST	
	$
TOTAL I	$

J. Indirect Costs

LIST RATE, BASE OF COMPUTATION AND NEGOTIATING AGENCY	
	$
TOTAL J	$

PART I, SECTION D-2, FINANCIAL DETAIL - FACILITIES

K. Construction - Engineering Plans

	$
TOTAL K	$

PART I, SECTION E, PROJECT SCHEDULE

1. DATA ON CONTRACTS

A. HAVE ANY CONTRACTS BEEN AWARDED? ☐ YES ☐ NO

B. IF YES, LIST THOSE AWARDED *(Give purpose of contract, name of contractor, and date awarded)*

2. APPLICANT IS PREPARED TO MAINTAIN THE FOLLOWING SCHEDULE

(Not applicable to Class I Grants)

ITEM	NUMBER OF CALENDAR DAYS
A DAYS REQUIRED TO COMPLETE PRELIMINARY STUDIES AFTER GRANT OFFER IS ACCEPTED	
B DAYS REQUIRED TO COMPLETE ENGINEERING REPORT FOR PROPOSED PROJECT AFTER GRANT OFFER IS ACCEPTED	1095
C DAYS REQUIRED FOR PLANS AND SPECIFICATIONS TO BE READY FOR ADVERTISING FOR BID AFTER GRANT OFFER IS ACCEPTED	
D DAYS REQUIRED TO LET CONTRACT FOR CONSTRUCTION AFTER GRANT OFFER IS ACCEPTED	
E ESTIMATED TIME TO COMPLETE CONSTRUCTION AND INITIATE POST-CONSTRUCTION STUDIES	
F ESTIMATED TIME REQUIRED FOR POST-CONSTRUCTION STUDIES	
G ESTIMATED TIME REQUIRED AFTER POST-CONSTRUCTION STUDIES FOR PREPARATION OF A FINAL TECHNICAL REPORT TO EVALUATE FINDINGS	

PART II, DETAILED PROJECT DESCRIPTION

(Part II of the application shall provide a detailed description of the project plan, supporting information, and miscellaneous information. The description shall be prepared in accordance with the Instructions for completing Part II to assist in the review of this application. Begin here and use continuation pages as necessary.)

Section A, PROJECT PLAN

U. S. GOVERNMENT PRINTING OFFICE: 1969 O - 349-784

PART II, DETAILED PROJECT DESCRIPTION

SECTION A, PROJECT PLAN

REGIONAL WATER QUALITY-QUANTITY SYSTEMS ANALYSIS

1. Project Objectives

The broad goals of this work are: (1) to develop and demonstrate a pragmatic methodology for total planning of an integrated water supply-liquid waste handling system on a regional metropolitan scale involving a consortium of local political entities, and (2) to develop a river basin pollution control plan. The specific objective of this project is to develop a plan to meet present and future water quantity-quality requirements for the various categories of water use (domestic, industrial, agricultural and in-stream). The achievement of this objective will require, of necessity:

a) defining the size, location, and time phasing of added facilities for physical transfers of water (in main water supply header and trunk waste lines)

b) defining size, location and time phasing of necessary added facilities for effecting quality improvements in the water (i.e. water treatment, waste water treatment, tertiary treatment, desalting).

c) developing a hydro-quality simulation model for the important streams.

Objectives (a) and (b) will be designed to accomplish the objectives of a "regional plan," as defined by the "Guidelines-Water Quality Management Planning," Environmental Protection Agency, January, 1971 (hereafter called "Guidelines"). Objective (c) will be designed to

accomplish the "basin plan" as outlined in the Guidelines. Principal emphasis will be on the regional plan.

Additional peripheral objectives are to examine the effect on the minimum system cost of: (a) modifying a goal (such as for in-stream water quality), (b) foregoing certain uses (i.e., allowing the purchase of water rights), (c) developing new supplies (e.g., ground water), (d) consolidating organizations (i.e., compare the minimum cost of the system designed for a conventional fragmented institutional array with that of a basin water utility firm) or (e) modifying the physical boundaries selected.

We should emphasize that a major goal implicit in our objectives is to develop pragmatic guidelines for total water quantity-quality planning in a systems context. The demonstration of the applicability of system analysis concepts and the actual implementation of a policy deduced from optimization procedures for a consortium of real water using political entities oriented about the objectives of the Guidelines, are perhaps the most important goals of this proposal.

2. Need for Proposed Work

Over the past decade the concepts of system analysis have penetrated the water resources field (in this proposal the term is meant to include the water quality as well as the quantity aspects). However, an eminent practitioner, Leo R. Beard, Director, The Hydrologic Engineering Center, Corps of Engineers, pointed out that as of 1968 he knew of no specific application of systems analysis in actual design (1). Since then an abundant literature has appeared on various aspects of system analysis (see Appendix B) and contains no contradiction to this statement. In

1970 L. R. Beard (2) restated his earlier comments in a somewhat less categoric way.

Implementation of systems analysis principles into project design is a formidable task. The charter of the planning organization may be too limited in scope; expediency in accomplishing the most pressing and quickest solutions may be necessary; institutional constraints, are more often than not a major impediment; data requirements may be ill defined. Also, the subject is new and there are few individuals who have more than a partial grasp of the subject. Those who are well versed have literally pulled themselves up by their bootstraps, so to speak. A good comprehension of economics, capabilities in operations research, a more sophisticated computer orientation, some grasp of the political and social institutional dimensions, a thorough knowledge of the physical dimensions of the problem, and then a comprehension of real world limitations related to data procurement, budget constraints--all of these qualities, in a genuine sense, are hard to find in all but a few individuals.

Practitioners who are cognizant of the benefits of the systems approach are increasing; they complain, however, of the massive and unrealistic data requirements, nebulous or abstruse functional relationships, and the myriad of other details that make the difference between theory and practice.

The proposed project meshes with this evolutionary development of systems analysis in two ways. First, in a general way, this project is designed to bridge the gap between theory, numerous particular exercises in operations research, discussions-and absorption of systems analysis principles into engineering practice. Though subtle, and not necessarily formalized in discussion elsewhere, this is perhaps a most important

benefit. Second, our application of systems analysis principles will articulate methodology for implementing in an enlightened and comprehensive manner, a number of poignant present day concepts in waste management. These concepts include: water reuse, regionalized treatment plants, comprehensive basin planning in both quality and quantity dimensions, and total water planning in terms of both the supply side and the waste side in an irrigated-urban-recreational regional economy located in a semi-arid climate. The arid character of the region magnifies the dichotomy between pollution control in-streams and intensive use of a limited supply of water as practiced in the Western States.

The merits of these concepts have been recognized for several years by the Federal Water Quality Administration. This cognizance began formally with the Clean Water Restoration Act of 1966, which provides financial incentives for regional planning of waste treatment plants. The planning provision of the act has been essentially dormant since enactment, however, even though guidelines for grant applications have existed since August 1967. More recently, this provision has been reinforced with the administrative stipulations that: (1) water quality standards will be enforced, and (2) allocation of federal grants for municipal treatment plants will require the existence of a comprehensive river basin or regional plan (as defined by the Guidelines).

The implementation of systems analysis techniques and approaches is now a necessity. Even a casual look at the E.P.A. guidelines (3) should convince the reader that it is virtually impossible to meet the listed requirements without at least some elementary use of system analysis and optimization.

For example it is stated (Reference 3, page 2A-3, 2b, Optimization Analysis) that "A general discussion of the requirements for determining a cost-effective strategy for water quality management was provided in Chapter 2. For certain cases, tradeoffs between alternatives may be obvious without formal mathematical analysis. For many cases, however, efficient combinations of water quality management tactics cannot be assured without more demanding mathematical analysis procedures."*

Though now necessary, the implementation of systems analysis techniques remains difficult because these concepts have not yet been translated and absorbed into engineering practice. The current conventional planning approaches will surely fall far short of a total planning perspective intended unless both systems analysis techniques and attitudes have penetrated such planning.

3. Plan of Operation

The individual steps for execution of project objectives are enumerated as follows:

a. Definition of the regional system.

The regional/metro system and adjacent river basins must be large enough and diverse enough in their water using characteristics, and possess significant present and/or potential quality-quantity problems, such that the demonstration holds promise of a significant application of systems analysis, and is amenable to gleaning specific articulation of systems analysis methods applied to a real system. It is important also, for our purposes, that the system chosen be tractable in terms of its size, its complexity, and its data availability in relation to project objectives, budget, and personnel.

*Underlining, ours.

The selected area falls under the jurisdiction of the Larimer Weld Regional Planning Commission. It includes the Poudre and Big Thompson River basins and the fraction of the South Platte basin within the two counties. Figure A-1, Appendix A, shows the project boundaries, and defines the location with respect to State boundaries and Denver.

The demonstration area shown in Figure A-1 contains a diversity of use categories and a large multiplicity of use entities each administered and operated by separate water districts and sewer districts. This area contains of the order of 720,000 acres of irrigated land (4), using of the order of 1.5 million acre feet annually; about 40 industries (5), using probably of the order of 10,000 acre feet annually; and some 30 domestic entities (5) using in aggregate about 35,000 acre feet (6). Currently there are 12,000 water metered customers in the Fort Collins urban area (pop. 47,300 in 1970 -- without students); 38,000 are projected for year 2000 (population 146,000 projected (6)).

The projected Fort Collins municipal demand for year 2020 is 70,000 acre feet. Within the Larimer Weld region, there are some 30 municipal water districts (5), 9* sewer districts, and 32** irrigation ditch companies which have responsibility for water. Also, there are 11 existing or planned waste treatment plants 1/ and 10 water treatment plants (5). Also within the Poudre River, the disparity between existing and desired water quality goals is currently very great (9, 10). Currently, Larimer County is sponsoring the development of a regional plan for both water supply and sewage collection and treatment. This effort

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* Larimer County only (7).
** Poudre River Basin (8).
1/ The DTT Chamber report (6) (p. 8) projects a 150% increase in sanitary sewer facilities will be required by 2000, from 10.5 mgd in 1970 to 25 mgd in 2000.

will provide a key source of data and a core of ideas for feasible location of header and trunk lines and one set of alternatives for size and location of waste treatment facilities. Our work would use these current studies as a basis for extension into total comprehensive planning, which will examine additional alternatives in size, location, and type of treatment, and will introduce optimizing techniques. Appendix A describes this two county study area in more detail.

b. Development of a suitable framework for analysis and data utilization.

We plan to use the mass balance principle to model the quantity-quality characteristics of the regional system. The application of the principle to both quantity and quality is visualized best for the whole system of many individual uses and in-stream changes by the use of tables (or matrices) detailed to the desired degree of resolution. Figures 1, 2, and 3 show how the matrices display a virtually complete description of the system. All possible system combinations and permutations can be made evident. The application of these matrices is explained in detail by Bishop and Hendricks (1971) (11), where they were used in a linear programming formulation of water reuse systems analysis.

We should emphasize that Figures 1, 2, and 3 are for illustrative purposes only. A more complete elaboration involving numerical entries and further development of categories of origins and destinations, would be premature at this time.

Figure 2 shows how the quality dimension is evaluated. Each numerical entry is the quality change that would have to be effected by treatment; the less than 0 entry means the supply quality exceeds that required. These figures are the difference between the effluent

Origin \ Destination	Reach B	Diversion 1 a Water Dist.	Diversion 2 B Water Dist.	Ft. Collins Water Treatment Pl. #1	Ft. Collins Water Treatment Pl. #2	Colorado Trout Hatchery	Hansen Canal	Ft. Collins #1 Pl.	Boxelder San. Dist. Ox. Pond	Ft. Collins #2 Pl.	South Ft. Collins San. Dist. Ox. Pond	Proposed Plant	Proposed Windsor Pl.	Reach E	Reach F	Category Avail.
Poudre R Reach A	X															X
Poudre R Reach B		X	X	X		X										X
																X
Horsetooth Res.					X		X									X
																X
																X
																X
City of Ft. Collins								X		X						X
Boxelder San. District									X							X
South Ft. Collins San. District											X					X
																X
Ft. Collins Tr. Pl. #1														X		X
Reach E															X	X
Ft. Collins Tr. Pl. #2															X	X
																X
																X
																X
Use Sector Requirement	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	

Fig. 1. Illustrative Regional Matrix of Water Use-Poudre River in Larimer County - all entries designated X are annual or monthly quantities of use.

Origin \ Destination	Reach B	Diversion 1 a Water Dist.	Diversion 2 B Water Dist.	Ft. Collins Water Treatment Pl. #1	Ft. Collins Water Treatment Pl. #2	Colorado Trout Hatchery	Hansen Canal	Ft. Collins #1 Pl.	Boxelder San. Dist. Ox. Pond	Ft. Collins #2 Pl.	South Ft. Collins San. Dist. Ox. Pond	Proposed Plant	Proposed Windsor Pl.	Reach E	Reach F	BOD Effl. Degradation
Poudre R Reach A	X															
Poudre R Reach B		Δq_{ij}	X			X										q_i
Horsetooth Res.				X	X		X									
City of Ft. Collins								X								
Boxelder San. District									X							
South Ft. Collins San. District										X						
Ft. Collins Tr. Pl. #1														X		
Reach 1															Δq	
Ft. Collins Tr. Pl. #2															Δq	
BOD Infl. Requirement	q_j															

Fig. 2. Illustrative Tableau Matrix of Water Quality Differentials - entries are quality demands on the bottom row and quality availability on the right column and quality differentials in the elements of the matrix.

Origin \ Destination	Reach B	Diversion 1 a Water Dist.	Diversion 2 B Water Dist.	Ft. Collins Water Treatment Pl. #1	Ft. Collins Water Treatment Pl. #2	Colorado Trout Hatchery	Hansen Canal	Ft. Collins #1 Pl.	Boxelder San. Dist. Ox. Pond	Ft. Collins #2 Pl.	South Ft. Collins San. Dist. Ox. Pond	Proposed Plant	Proposed Windsor Pl.	Reach E	Reach F	Category Avail.
Poudre R Reach A																
Poudre R Reach B																
Horsetooth Res.				C_{ij}												
City of Ft. Collins																
Boxelder San. District																
South Ft. Collins San. District																
Ft. Collins Tr. Pl. #1																
Reach I																
Ft. Collins Tr. Pl. #2																
Use Sector Requirement																

Fig. 3. Illustrative Tableau for Unit Costs - entries are unit costs (in dollar per acre ft) for treatment and transportation in making an i-j transfer.

(the extreme right column) and the influent quality demand (the bottom row). We could also approach the quality dimension from the standpoint of a mass balance of the particular quality factor; this could be used to determine the necessary amount of solids removal and an optimum treatment-dilution system to keep the flow system at desired quality levels.

Figure 3 is a tableau of fixed unit costs for each feasible transfer in the system. Each entry will be the cost of physical transport of water, Figure 1, plus the cost of treatment necessary as indicated by Figure 2. Figure 3 should be interpreted as conceptual for planning beyond exploratory stages. For detailed and definite planning, the entries in the elements of Figure 3 are cost functions reflecting scale (i.e., size of pipeline, pumps, etc., and size of treatment plant if necessary), degree of treatment (i.e., what constituents are to be removed and to what extent) and set-up costs (e.g., capital cost of acquisition of land). The variable cost functions and other factors are discussed in step d.

c. Data procurement for Larimer County, Weld County, and the cities of Fort Collins, Greeley, and Loveland.

Several categories of data will be needed; these include: (1) hydrologic (i.e., streamflows, ground water availability, consumptive use, rainfall, natural water quality --- all of which must be characterized regarding time and space distribution, stochastic nature, etc.) data; (2) diversions both current and projection of time demand, (3) quality changes caused by each use, (4) quality changes which can be effected by treatment, (5) costs functions for scale of transport and scale and type of treatment, and (6) population forecasts, forecast of industrial character of region, etc.

Much of these data will be collated from reports related to various and sundry development activities and studies in the region. These data will be supplemented by utilizing records from water using entities and from surveillance organizations. We anticipate the cost functions will be most difficult to obtain. Some original searches and construction of cost functions will probably be necessary; this is because cost functions are in the first place scarce, and in the second place, they may be somewhat deficient for intact application to immediate real problems at hand. Such original side studies will be minimized, but where necessary they will be kept pragmatic in nature. Again, we will demonstrate how to accomplish such necessary tasks rather than dwell on the end result. The population forecasts, and projections regarding the nature and character of the region will be synthesized through contacts with local sources. Goals in water quality will be determined by existing and projected water quality standards. Existing federal and state laws will be the primary guides for projected limits and character (i.e., stream standard, effluent standard) of the laws; this tangible information will be supplemented by local goals where they are formulated. Drinking water standards are readily available for the domestic supply side. Standards used for irrigation and the array of industrial uses will be guided by literature sources, supplemented by ascertaining local industry requirements.

- Growth Projections -

Several design target dates must be designated in order to properly determine the phasing of individual facilities. This information will be supplied through the Larimer and Weld County Planning

Offices and county health departments. Demands for water and effluent quantities must be projected into each water using sector. Such projections are inherently "uncertain" (we use the term "uncertainty" in its mathematical sense as well as its conventional connotation). Our models should accommodate the uncertainty factor in the system design; the systems analysis algorithm can, in fact, include the uncertainty factor.

Also, our plan should contain flexibility in its schedule for implementation, such that better options not presently foreseeable are not closed. Such changes might be caused by errors in growth projections, economic character of the region, and social goals of the region.

- Constraints -

The term "constraints" is used in its mathematical sense, to indicate the limitations within which a solution must take place. These include both man imposed requirements, and the nature of the water supply and river systems as found in nature and after modifications by man (i.e., Horsetooth Reservoir). The existing waste collection system and treatment system are included also. Virtually all of these constraint categories can be characterized mathematically. Other categories include: (1) legal, such as water rights, water quality standards; (2) social, such as aesthetic goals for the adjacent land use and for the uses of the stream system (these may be destined to become legal constraints, upon action through the political process); (3) physical, such as the natural inflow quantity and quality characterized mathematically.

- Sampling -

In addition to utilizing data currently available, both published and unpublished, a substantial amount of sampling and flow measurement must be done to satisfy the specific needs of the project. These tasks, involving both sampling and analysis, will be accomplished by the Larimer County Health Department. This department has, in fact, an active sampling program in Larimer County at the present time. The extensive amount of data which has been accumulated up to this time by the Larimer County Health Department, and several other organizations, must be transferred to punched cards so that they are compatible with project requirements. These data will be processed and displayed in both tabular and graphical form in time and distance, similar to that described by Dixon, Hendricks, Huber, and Bagley, 1970 (12).

- Data Assembly -

This phase must be given priority over the development of the models (discussed in the following sections) because of the systematic nature of the study. The nature, availability and degree of completeness of the data will condition partly the model. The efficient processing of the data in a form compatible with the system is also very important. It must be viewed as a standard procedure to be used later on by the agencies under the authority of the Larimer Weld Regional Planning Commission.

d. Solution algorithms for least cost.

Linear programming - Figure 3 illustrates the basis for optimization by the "transportation algorithm," from linear programming. If we designate i as the particular row in the matrix, or category

availability; and j as the column designation, or use category; and X_{ij} as the amount transferred from the particular i origin to the jth destination; a_i as the total category availability; b_j as the use demand; m as the number of origins (rows); n as the number of uses (columns); c_{ij} as the unit cost of treatment plus transport to deliver acceptable water from i to j; and TC as total cost, then we determine the amounts, X_{ij}, to be shipped over all routes so as to minimize total costs by the transportation problem, stated mathematically:

$$\text{Min } TC = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} X_{ij} \tag{1}$$

subject to the constraints:

$$\sum_{j=1}^{n} X_{ij} = a_i \qquad i = 1,2,\ldots m \tag{2}$$

$$\sum_{i=1}^{m} X_{ij} = b_j \qquad j = 1,2,\ldots n \tag{3}$$

We also impose the restriction that $\sum^{i} a_i \leq \sum^{j} b_j$. We have here $m+n$ equations in $m \cdot n$ variables. The solution is readily found through application of linear programming techniques which have been developed in package form. Bishop and Hendricks (11) and Bishop, Hendricks, and Milligan (13), have shown how to apply this technique to meet expanding quantity demands for water with a fixed water supply, while meeting water quality objectives for the Salt Lake City agro-urban system up to the year 2020. Their results show when to phase in tertiary treatment and desalting, give the size of plants needed, then

show all feasible trade offs for sequential water reuse which are cheaper than tertiary treatment and desalting.

Their approach is adequate for an initial gross scale planning. However, this is not adequate for the specific level planning which must be done at a finer degree of resolution. To accomplish this we must impose the conditions of reality to a greater degree. The most obvious and important of these new conditions relates to the scale effect; that is unit costs, c_{ij} , are not constant, but are some function of the scale of the facility. The transportation problem algorithm is not adequate for handling problems involving unit costs which are a function of scale.

The transportation problem does serve a purpose, however, in defining a useful conceptual framework for displaying the elements of the problem in total perspective. It is also useful in obtaining gross solutions for initial planning.

Thus, while we will preserve the concept of the "transportation problem", we must find other algorithms for solution which fit the conditions of reality. Considering the scale effect (i.e., size of pipeline or plant) on unit cost offers one of the greatest potentials for finding economy.

Non-linear methods - To define an algorithm which considers the scale effect we use the linear programming algorithm (transportation problem) as the point of departure. As mentioned, unit cost, c_{ij} , varies with the transferred amount, decreasing as the transferred amount increases. Now one can speculate (it is only a speculation)

that the unit cost decreases linearly with volume X_{ij} . The mathematical statement is:

$$c_{ij} = B_{ij} - c_{ij} X_{ij} \quad . \tag{4}$$

The constraints of the problem are unchanged and the only difference with the transportation problem formulation (Eqs. 1, 2, 3) is that the objective function has the form:

$$TC = \sum_{i=1}^{m} \sum_{j=1}^{n} (B_{ij} X_{ij} - c_{ij} X_{ij}^2) \quad . \tag{5}$$

It is no longer a linear expression but a quadratic one. The problem of minimization of a quadratic objective function such as the one given by Eq. (5) subject to the linear constraints given by Eqs. (2) and (3) is a standard Quadratic Programming problem for which various (14, 15) solution algorithms exist. Again, the problem can be solved easily but the computer costs go up. But, such costs are still relatively small in this case. The optimal policy will show gradual rather than abrupt phasing in and out of sources of supply for a given use. (The linear programming will result in abrupt shifts in such phasing; this can be overcome somewhat by parametric programming as outlined by Bishop, Hendricks, and Milligan, (13).)

One must remember that the linear form of the decrease of the unit cost with volume transferred is only a speculation. Suppose the unit cost decreases non-linearly with volume transferred. Now the problem is one of minimization of a non-linear but convex objective function subject to linear constraints. Again, the problem can be solved by a solution algorithm known as the Jacobi Differential Algorithm (15).

(An alternative is Dynamic Programming though in view of the probably large dimensionality not an attractive one. However, a recent variation (16) namely the Discrete Differential Dynamic Programming eases the memory and computer time requirements of traditional D.P.). In essence the differential algorithm consists of linearizing (locally) the non-linear objective function, the equality and inequality constraints and of eliminating (implicitly) the state variables from the objective function and the constraints. The rate of change of any function, expressed only in terms of decision variables, with respect to one decision variable is called the constrained derivative of the function with respect to that variable. The algorithm to iteratively increase the objective function is very similar to the Simplex procedure of linear programming except that the interchange of a basic with a non-basic variable is not the only possibility. Interchange among decision variables is also possible. This results from the fact that for non-linear problems at the optimum a decision variables is not necessarily zero if the corresponding constrained derivative is zero. The algorithm stops when the Kuhn-Tucker conditions are satisfied.

Speculating further, it is quite possible that the cost C_{ij} not only depends on X_{ij} but also on $X_{\ell m}$ if source i is a secondary source depending on the effluent of use m. Then, the total cost function will include terms of the form (possibly): $(X_{ij})^{\alpha}(X_{\ell m})^{\beta}$. In this case, the Differential Algorithm is still applicable (Geometric Programming (17, 18) becomes an attractive alternative (19) but Dynamic Programming is out).

One degree of speculation further will lead to a minimization problem of a non-linear objective function with non-linear constraints. A differential Algorithm solution is still feasible.

This discussion should have shown the futility of speculation concerning the exact form of the Mathematic Programming problem. Close study of the Real System will reveal that form and the case should not be prejudiced beforehand. In addition, the discussion should have shown that System Optimization is not to be equated with Linear Programming and is advanced enough to justify the effort of trying to apply it to a Real System. Finally, it should have shown that a careful analysis of the cost functions based on past available data for the system is needed in order to discover at least an approximate structure to the Mathematical Programming problem.

Effects of Seasonal Demands and Supplies

In a previous section a non-linear version of the transportation problem was discussed. It was based on average annual values for the supply and for the demand. The model is valid only to the extent that the long-term trend of increase in annual demand is the predominant feature of the system and that it shadows both the seasonal variations in demand and the chance fluctuations in supply. Typically, the demand has definite variations with season but minor chance fluctuations. For example, in residential suburban areas of the county, typically the domestic water consumption is low in the Fall-Winter season and doubles in the Spring-Summer period. The ratio of consumption in the two periods is very stable regardless of the summer weather conditions. In this case, the demand has a pronounced seasonal character but practically no random variations. The agricultural demand will have similar characteristics.

On the other hand, the surface water supply displays under natural conditions both pronounced seasonal variations and considerable chance fluctuations. Typically, the April-September runoff is 10 times the October-March runoff (20) and the coefficient of variation (standard deviation/mean) of yearly flow averages around 30% (21). In layman's terms, this last figure implies that within a six year record of flow, there is almost certainty that the flow for the wettest year will be about twice that for the driest year. This result, of course, only applies to the natural flow. For well regulated streams with large reservoir capacities (22), much of the stochastic nature of the flow has been removed.

Generally speaking, it can be said, nevertheless, that the demand displays definite seasonal variations whereas the supply may not have a negligible chance behavior.

The transportation model can easily be modified to account for the seasonal variations in demand. It suffices to define the new variables X_{ijk} to correspond to volumes of water transferred from source i to use j for season k, with corresponding changes in the total cost objective function and the demand constraints. Roughly speaking, the size of the problem to be solved doubles if the year is divided into two seasons, triples if it is divided into three seasons, etc. For the Larimer-Weld region, the division in four seasons (not necessarily equal) may provide a sufficiently detailed picture of the system.

Stochastic Fluctuations

The problem of the system may be viewed as a scheduling problem with uncertain and, therefore, variable supply. One can distinguish

two types of scheduling, for the short and for the long run. For the long run, "the effect of chance events is reduced to a minimum by the usual technique of providing plenty of fat in the system...with the hope that it will be a shock absorber, which will permit the general objective and timing of the plan to be executed in spite of unforeseen events. More precisely, the fat is introduced into the system so that, whatever be the random unforeseen event, the activities chosen will still be feasible" (23) or in other words, all the water needs can be met. "The effect of chance events is also reduced to a minimum by the technique of providing plenty of slack in the system. By this we mean the scarce exogenous inputs to the system are estimated on the low side, so that it is highly unlikely for the set of chosen activities" (say meeting the water needs) "to be infeasible because of shortages," (unexpected low flows) (23). As long as water availability is well above demand or if the demands can be shifted in time, the "slack" or "fat" techniques can be employed. For years of drought, short-run scheduling on this basis, coupled with the fact that agricultural water demands cannot be shifted in time, will lead to actions far from optimal.

To the contrary of the well categorized types of mathematical programming for deterministic problems, there are no standard approaches to optimization under uncertainty. "One of the basic difficulties is that the problem is capable of many formulations." (23) The particular formulation finally selected will depend on the actual characteristics of the system under investigation.

Nevertheless, for the sake of illustration, let us consider the case of the allocation problem with variable costs. Clearly, this is an actual problem. The costs associated with treatment and distribution, their dependence on scale of plant or trunkline, etc., are not

exactly known. There will be a distribution (in the statistical sense) associated with a range of cost values. The total cost objective function, namely (including seasonal effects):

$$TC = \sum_{k=1}^{K} \sum_{i=1}^{m} \sum_{j=1}^{n} C_{ijk} X_{ijk} \qquad (8)$$

where K is the selected number of seasons in the year, is a random function because the costs are random. In optimization, the objective must be well defined because it is not possible to optimize a random objective function. A convenient (if not rigorous) procedure is to optimize the expectation of the random objective function, namely,

$$TC^* = E(TC) = \sum E(C(X)X) \qquad (9)$$

where all subscripts have been dropped for brevity and the symbol $E(\ )$ means expected value of $(\ )$. The expected value of $C(X)X$ is no longer a random variable and it can be written as $\phi(X)$. Thus

$$TC^* = \sum \phi(X) \quad . \qquad (10)$$

The optimal X's, denoted $\hat{X}$, will minimize TC^*. The minimum value of TC^* is denoted $\hat{TC}^*$. Once this strategy is adopted, the actual total cost will depend on the actual costs so that the actual total cost corresponding to the $\hat{X}$'s, $\hat{TC}$, will vary more or less widely around $\hat{TC}^*$. If the range of fluctuation is broad, this may lead to unpleasant and embarrassing surprises. A strategy with a low expected total cost but also great variability may not be as desirable as a strategy which shows greater cost stability. Thus, instead of minimizing $E(TC)$, one may select to minimize the variance of TC, denoted V, namely,

$$V = E[(TC - TC^*]^2) \tag{11}$$

subject to the constraint

$$TC^* \leq \hat{TC}^* (1+r) \qquad r > 0 \quad . \tag{12}$$

This constraint expresses the fact that one wishes cost stability but not at any price. The strategies for choices of r of 10%, 20%, etc. can be studied parametrically. At a certain point, additional increases in total cost will not reduce risk significantly. One will settle for this reasonably reduced risk acquired at a moderate level of increase in total cost.

The random character of costs raised the question of how far off the actual total cost would be from a calculated minimal cost. It was not a matter of whether the plan will work or not, that is e.g., of whether the domestic water will meet the health standards or not. It was simply a matter of actual cost.

The random character of the water supply, particularly of the availability of the surface water supply or of the streamflow, raises an entirely different question. If an optimal strategy is calculated (and implemented) based on average river flows, the quality standards may not be met in years of low flow. It is not a matter of calculated versus actual costs. In this case, the cost is fixed. It is now a matter of whether the plan is working as it should. It is now a matter of feasibility. Will the plan remain feasible when the assumptions from which it was derived are violated? A possible remedy is to plan not under average conditions but on the basis of low flow, say the 1 in 20 years low flow. This is the typical "fat" or "slack" technique

referred to earlier in this section. It will guarantee that the plan will meet the constraints most of the time, practically all the time. With this technique planning is simple but excessive overdesign is guaranteed with the resulting associated unnecessary high costs. The plan has the advantage or disadvantage, depending on the viewpoint, to provide superior quality standards most of the time rather than acceptable legal standards. Another approach is to develop a plan based on assumption of a 1 in 5 years low flow, the regular plan so to speak and in addition, to have a contingency plan. The contingency plan is more costly but goes on operation only infrequently. The total objective function is a weighted combination of the most frequent (regular) cost and of the crisis cost. The weights correspond to the frequency of occurrences of normal versus contingency operations. The problem is the determination of the frequency of occurrence of a contingency. Most likely, no formal statistical derivation of this number is possible for a complex real system. However, that number can be estimated by simulation of response of the system to a generated sequence of hydrologic events (Monte-Carlo technique). In a somewhat different context (24) these ideas have already been put to use. In this reference the authors (after (25)) "defined the situation as one of "firming". This term implies the augmentation of low cost random supplies by means of a reliable higher cost supply."

It must be recognized at this stage that one can conceive two separate optimization problems. One addresses itself to the planning of water resources facilities to meet future needs, demands and standards under somewhat averaged conditions. Given the facilities, the second optimization problem addresses itself to the question of how to operate

the facilities in a most efficient way under realistic conditions. However for long-range planning of multiple facilities the two problems are not independent. The "linear decision rule" (26, 27) was developed for the joint problem when only one facility was to be designed (a dam (26)) and applied to a problem of the second type (optimal management given several facilities (24)). While conceptually the joint problem could be tackled for multiple facilities with "multivariate chance-constraints," for the Larimer-Weld counties region the two problems will most probably have to be tackled separately.

e. Definition of an initial array of reasonable alternatives.

The entries for the solution matrix must be broadly inclusive in initial stages, to incorporate as entries all vectors (i.e., row or column entry) which might possibly comprise part of a solution. The existing system of facilities will be the core to be expanded. Whether to enlarge existing plants, develop regional plants, allow transfers and trades in water will be screened through this comprehensive matrix. Any proposed facility and its size and arrangement in the system can be evaluated. Examples of facilities include storm sewers, dilution storage, tertiary treatment plants, desalting plants; examples of arrangements include whether say the tertiary plant should be a part of an existing secondary plant expansion or whether effluents from the existing secondary plants should be piped to a regionalized tertiary or desalting plant.

This initial array will be an expansion of previous and current studies (7) done within the study area for water and sewage facilities. These studies will be of considerable value in that many of the factors regarding location of trunk lines and treatment plants will have been examined.

Once all of these alternatives are listed, they can be screened for physical, social, political and financial infeasibilities.

f. Obtainment of the least cost solution.

In the previous step, we selected the individual row and column entries for the regional matrix. In this step, we must find the least cost optimum solution. We do this in accordance with the optimization procedures outlined in Step d.

g. Utilization of the least cost solution in planning the regional system.

(1) Refined cost estimates of system facilities

At this point, we must examine the least cost solution and find the parts of that solution which might be modified in a major way without affecting the system to a major degree. Further, the finer details of cost reality for this specific system must be incorporated. This includes labor costs, willingness of the management to operate the system properly, the refined cost estimates to include rights of way, more detailed consideration of construction costs, and other factors which will be more evident as the familiarity with the system evolves. Thus, we must engage initially in a preliminary design of the array of transport and treatment facilities and then repeat the least cost solution using refined matrix entries.

(2) Sensitivity analysis

Here, we wish to know also how sensitive the system is to relaxing or tightening certain controllable constraints, and to the cost estimates used, and to the quality of data procured. This information will show where to concentrate on in obtaining better cost estimates and data procurement.

We can also ascertain the effect of proposed social goals on the system least cost solution; this gives the opportunity cost of that goal. Also, if we relax a law, or assume a basin water firm, as contrasted with the current fragmented institutional array, we can assess the effect in least cost dollars.

The effect of physical boundaries can also be assessed. We can do this by considering the Fort Collins and Loveland areas separately and then together. Though not a definitive study, we may be able to glean some insight into how to draw economic boundaries for regional studies.

h. Definition of the system plan and facilities scheduling through target year.

In this step, we must translate our studies into a specific and tangible program. The time phasing, sizing, and location of plants, trunk lines, and main water distribution lines will be delineated. Should events and circumstances change prior to construction, such a program can and should be modified. A usable model, capable of updating and modification to fit circumstances will be a major project contribution, which should be capable of accomplishing any needed changes.

i. Delivery of an operational model to EPA.

We plan to develop our model to contain as much generality as possible. We will do this by means of subroutines, each containing a component, attached to a general solution algorithm. We will do this for two reasons: (1) the general plan of approach and the details for execution can be made intelligible to others, and (2) the details of

execution will differ not only in numerical inputs, but in method of approach for many details, characterized as subroutines.

In addition to the computer algorithm, we plan to outline a verbal solution algorithm illustrated on a small scale, but unsimplified, showing functional relationships for costs, etc., and solution methods. The value of our work may be primarily in the fact that it was done. This fact, per se, in addition to the specific mode of approach may be the prime value. Thus, the value of this proposed work can be assessed as follows in decreasing order of real world impact:

(1) A comprehensive water systems analysis has actually been done on a regional scale

(2) A general mode of approach--i.e., an algorithm of procedures applicable to a real system, has been outlined

(3) An operational systems analysis regional water planning model is available.

It should be stressed that the model per se will be designed to be generally applicable. To some degree the fact that the model will be developed for continuing applicability in time for the Larimer-Weld region will insure space transferability to other regions. In development of the computer programs great care will be exerted to separate the general aspects from the regional sides so that the same model can be used for other regions by changing the subroutines with regional vocation and only those. This can be achieved by careful (and stubborn) planning with constant attention to reduce the work of the user rather than that of the programmer.

The development of the computer models require work along two lines: conception and implementation. The implementation will require careful, professional programming (i.e., not by graduate students). Because of the regional rather than local character of the work, the running costs must be trimmed to the bare minimum.

j. Project organization.

Figure 4 is our concept of project organization. The goal of this organizational chart is to both fix responsibilities and to provide a line of authority which can work expediently in solving problems.

In this organization diagram, the Larimer-Weld Regional Commission is the policy making body; since this organization has no formal staff, the Larimer County staff and officials will act as staff for the Commission in general administration of the project. To insure proper inputs and considerations in both breadth and depth an advisory board will be established. This board will provide the necessary professional level, and political feedback, and planning liasons to insure that the project orientation is sufficiently inclusive. This type of feedback will also be sought on an unofficial basis.

The technical direction of the project will be the responsibility of the CSU project directors. They will be responsible to the Grant Director, Larimer County Commissioner, William Manuel, for the development of acceptable regional and basin plans. They will participate in all phases of the project.

Further approval bodies include the Colorado State Health Department and the Environmental Protection Agency, who must approve the basin and regional plans. The latter organization must also accept the planning

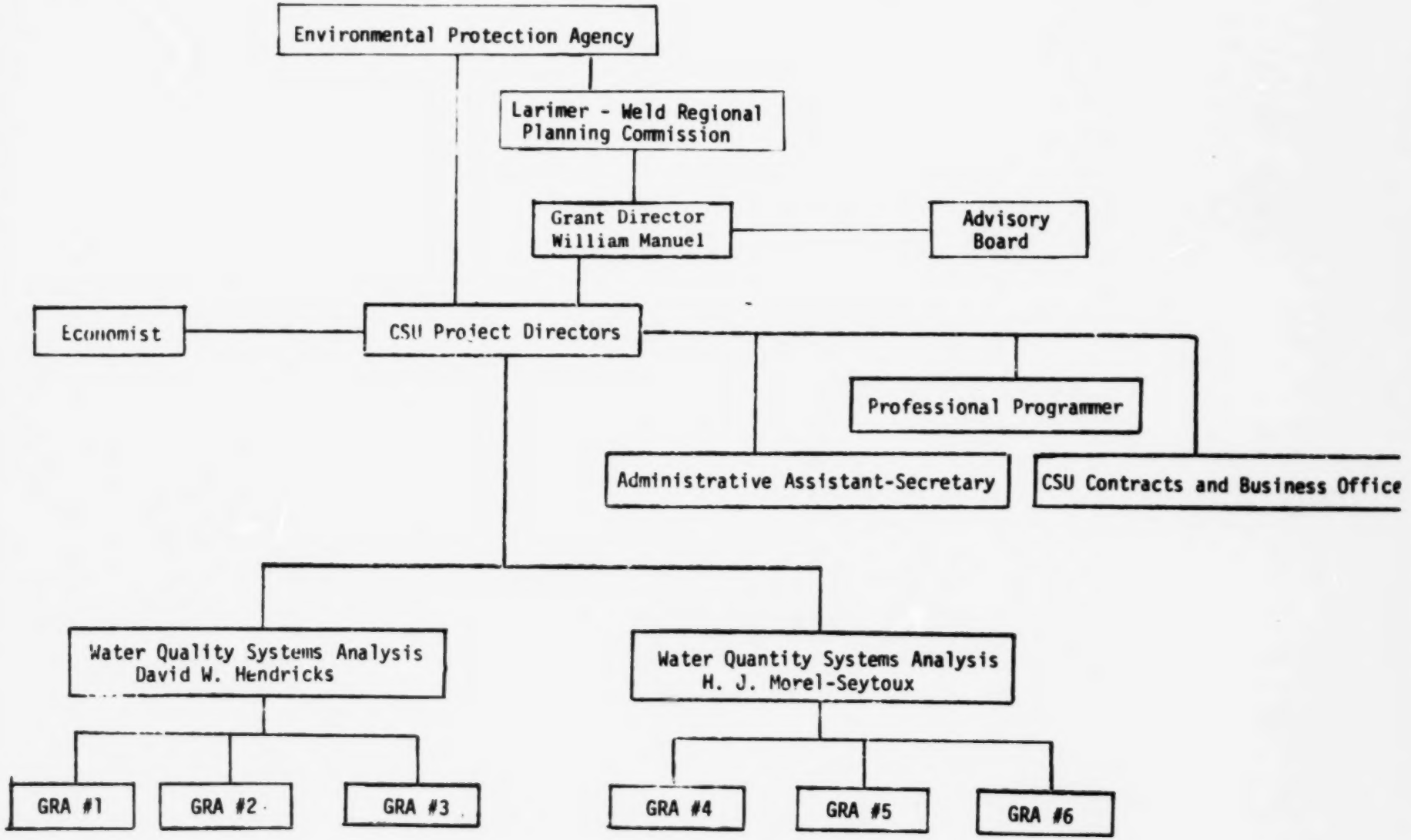

Figure 4 General Organizational Structure for project execution

model and report for its generalized value for efforts of a similar nature in other regions.

The CSU project directors will be directly responsible to EPA for the development of the general models to be transferable to other regions.

Table 1 shows how each task in project execution and operation is to be accomplished. The project will be managed by use of an expanded Table 1 and by the PERT-time diagram, Figure 5.

In the PERT diagram all dates must be understood as relative to funding date assumed optimally to be September 1, 1971. If funding is delayed all dates must be modified accordingly.

k. Regional Plan and Basin Plan.

A Comprehensive River Basin Plan and a Regional Plan is to be presented to the Colorado State Health Department, Colorado Planning Commission and the Environmental Protection Agency for certification. These plans are to meet the requirements of the 1971 guidelines. We feel this proposed project is oriented to vividly and lucidly accomplish the intended goals of these guidelines.

Table 2 articulates further the relationship between the Larimer-Weld Regional Planning Commission (LWRPC) and Colorado State University (CSU), in developing the operational basin and regional plans.

Table 1. Work Distribution Project Tasks

Task Description	W.C.M.	D.W.H.	H.J.M.	Secretary & Ad. Assi.	GRA 1	GRA 2	GRA 3	GRA 4	GRA 5	GRA 6	Profess. Programmer		EPA Project Officer	CSU Contracts & Grants Office
Project General Orientation	X												X	
Project General Direction and Responsibility	X													
CSU subcontract project direction and Responsibility		X	X											
Project Overall Technical Direction	X	X	X											
Project System Analysis Direction		X	X											
Fiscal Control	X	X	X											
Fiscal Operations	X			X										X
Quarterly Progress Reports	X	X	X											X
Fiscal Quarterly Reports	X													
Literature Searches					X	X	X	X	X	X				
Physical System Data Procurement					X			X						
Cost Data Procurement						X			X					
Growth Projections Data	X													
Data Analysis					X	X		X	X					
Data Analysis Review	X	X	X											
Regional Model Design	X	X	X											
Delineation of constraints														
physical	X	X	X											
social	X	X	X											
political	X	X	X											
economic	X	X	X											
Delineation of system component alternatives	X	X	X											
System Mathematical Description					X	X	X	X	X	X				
System Optimization							X			X				
Optimization Algorithms							X			X	X			
Computer Programs							X			X	X			
Sensitivity Analysis	X	X	X				X			X				
Opportunity costs of alternative policies	X	X	X				X			X				
Hydro-quality Simulation Model						X			X					
Basin Plan		X	X			X			X					
Optimal Policy	X	X	X				X			X				
Delivery of Operational Model to EPA		X	X				X			X	X			
Specific Selected Regional Plan in time and space	X	X	X											

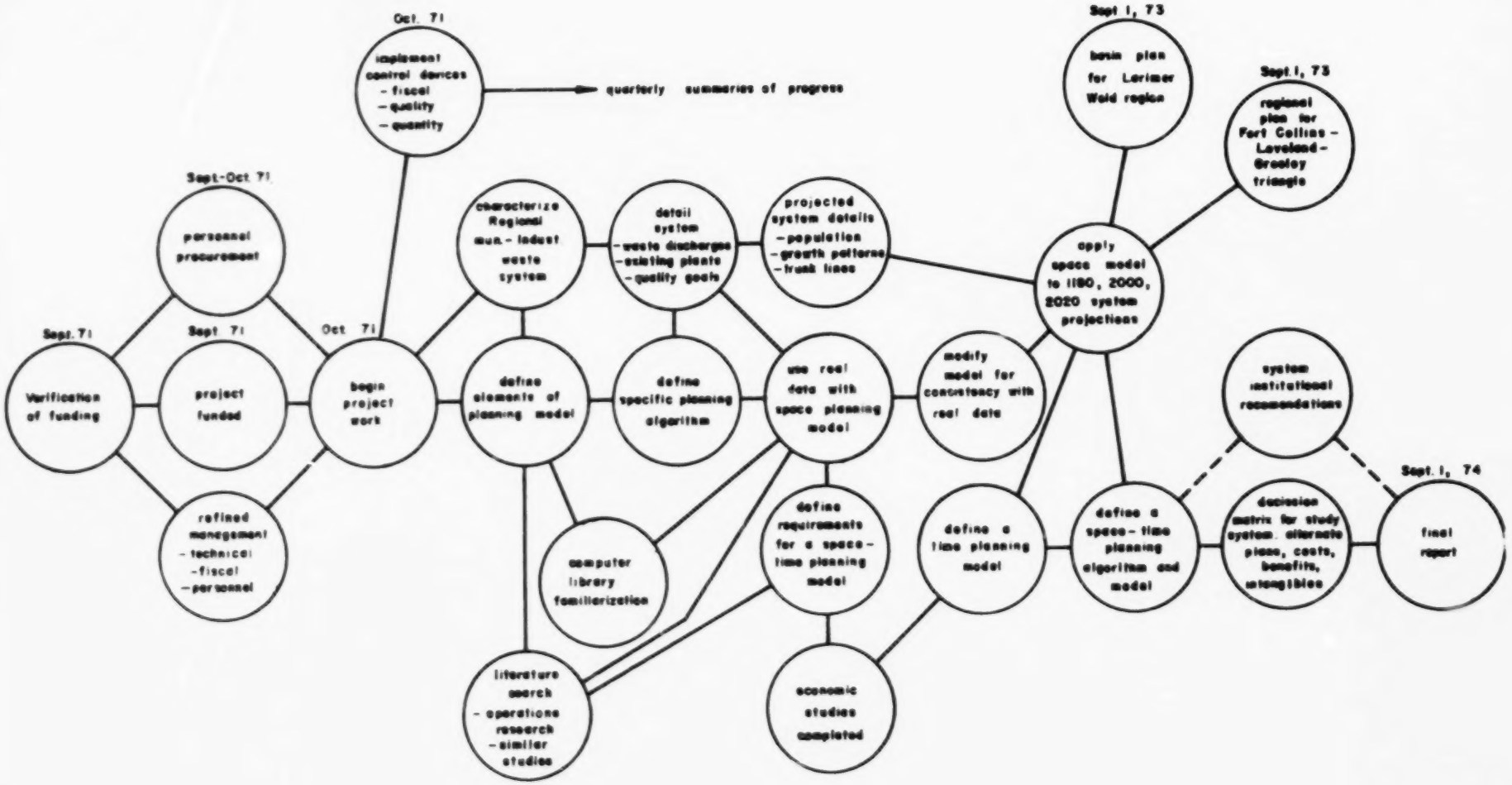

Figure 5 : PERT Diagram to Show Anticipated Scheduling and Tasks for Operation of Project

TABLE 2. RELATIONSHIP BETWEEN THE LARIMER-WELD REGIONAL PLANNING COMMISSION AND COLORADO STATE UNIVERSITY IN DEVELOPING BASIN AND REGIONAL/METRO PLANS

Execution LWRPC			Model Building - Innovation CSU
(1)	Provide necessary coordination between political and district entities	→	(1) Assimilate feedback into model development
(2)	Develop water quality objectives for region	→	(2) Assess opportunity costs for stated objectives
(3)	Provide land use plan	→	(3) Constraints implied on location and architectural design of treatment facilities
(4)	(a) Select a feasible plan (b) Provide drawings and preliminary sketches of facilities (c) Develop fee schedule for operation and amortization of facilities (d) Draw up legislation, as necessary, for implementing plans	←	(4) Provide alternate plans for regional water quality management including type, sizes, locations, time phasing of facilities
(5)	Develop means for continued administration of plan and for continuing revision	←	(5) Develop models for continued routine use for planning and operation.

4. Project Facilities

This work will be performed primarily at the Engineering Research Center, a large three-story office and laboratory building located at the Foothills Campus, Colorado State University. This building is used by graduate students and faculty in the various research programs in the College of Engineering; the sanitary engineering program occupies about 2200 square feet. The building is rather complete in the support facilities provided, such as library reading room and library procurement service (with main library), card punching services, and computer center remote terminal, etc.

The facilities required for this project will be office and computational space for six graduate students and a secretary, which can be provided. The CSU Computer Center computer is a CDC 6400, located in the Engineering Building. This computer is adequate in storage and speed for the modeling requirements of this project. A remote terminal to the CDC 6400 is located at the Engineering Research Center. The immediate turn around time provided by this terminal results in significant economy of time over the conventional procedure.

Larimer County offices and laboratories will be available and utilized also. The laboratories of the Larimer County Health Dept., are particularly well equipped and staffed and will be depended upon for most of the supplemental sampling and analysis required. These activities are currently quite vigorous in the program of this health department.

5. References

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2. Beard, L. R. "Some Remarks on Reservoir System Design." Paper presented at ASCE Water Resources Conference, July 9, 1970.

3. Environmental Protection Agency. "Guidelines - Water Quality Management Planning." Water Quality Office, Washington, D.C. 20460, January 1971.

4. Northern Colorado Water Conservancy District. "Thirty Third Annual Report 1969-1970." District Office, U.S. Highway 34, P. O. Box 679, Loveland, Colorado.

5. Larimer-Weld Regional Planning Commission. "Interim Water and Sewer Planning." P. O. Box 2137, Fort Collins, Colorado 80521, Service Building, Greeley, Colorado 80631, April 1971.

6. Fort Collins Chamber of Commerce. "Designing Tomorrow Today." Assumptions Committee Report, December 1970.

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8. U. S. Bureau of Reclamation. "Concluding Report, July 1966, Cache La Poudre Unit, Longs Peak Division." Region VII, Denver.

9. Misbach, G. "Comprehensive Survey of Cache La Poudre River - May 5 through June 12, 1970." Water Pollution Control Division, Colorado Dept. of Health, 1970.

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13. Bishop, B. A., Hendricks, D. W. and Milligan. "Assessment Analysis for Water Supply Alternative." Water Resources Bulletin, Journal AWRA, Vol. 7, No. 3., June 1971.

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18. Scherfig, J., Schinzinger, R. and Morgan, T. W. "Waste Treatment Optimization by Geometric Programming." Presented at the 5th International Water Pollution Research Conference, San Francisco, July-August 1970.

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20. Morel-Seytoux, H. J. "Suitability of Basins to Weather Modification and Statistical Evaluation of Attainment." Final Report to Bureau of Reclamation, Office of Atmospheric Water Resources, Colorado State University, Part 1, 62 pages, July 1, 1968.

21. Nakamiche, H. and Morel-Seytoux, H. J. "Suitability of the Upper Colorado River Basin for Precipitation Management." Hydrology Paper No. 36, Colorado State University, 62 p., October 1969.

22. Northern Colorado Water Conservancy District. "With Water enough--A Better Land!" Leaflet, P.O. Box 679, Loveland, Colorado.

23. Dantzig, G. "Linear Programming and Extensions." Princeton University Press, 632 p., 1963.

24. Joeres, E. F., Liebman, J. C. and Revelle, C. S. "Operating Rules for Joint Operations of Raw Water Sources." Journal Water Resources Research, Vol. 7., No. 2, pp. 225-235, April 1971.

25. Willis, J. M. "Joint Operation of Gravity Reservoirs and Pumped Supplies." Ph.D. Dissertation, John Hopkins University, Baltimore, Maryland, November 1960.

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26. Revelle, C., Joeres, E. and Kirby, W. "The Linear Decision Rule in Reservoir Management and Design. 1. Development of the Stochastic Model." Journal Water Resources Research, Vol. 5, No. 4, pp. 767-777, August 1969.

27. Revelle, C. and Kirby, W. "Linear Decision Rule in Reservoir Management and Design. 2. Performance Optimization." Journal Water Resources Research, Vol. 6, No. 4., pp. 1033-1044, August 1970.

28. Larimer Weld Regional Planning Commission. "Interim Water and Sewer Planning - Region 2." P. O. Box 2137, Fort Collins, April 1971.

PART II, SECTION B, SUPPORTING INFORMATION

1. Project Personnel

a. Larimer County

Grant Director	William C. Manuel, Larimer County Commissioner
Regional Technical Coordinator	Douglas Wigle, Director, Larimer County Health Dept.
Regional Planning Coordinator	Dwight Whitney, Larimer County Planner
Field Technicians (2)	
Laboratory Technicians (2)	

b. Weld County

County Planner	Burman Lorenson
Chief Sanitarian	Glenn V. Paul, Weld County Health Department
County Engineer	Byron Ewing
Sanitary Technician	

c. Colorado State University

Project Co-Director	Hubert J. Morel-Seytoux, Assoc. Prof. of Civil Engineering
Project Co-Director	David W. Hendricks, Assoc. Prof. of Civil Engineering
Economist	To be selected
Graduate Research Assistant	To be selected Graduate student
Graduate Research Assistant	To be selected Graduate student
Graduate Research Assistant	To be selected Graduate student
Graduate Research Assistant	To be selected Graduate student

PART II, SECTION B, SUPPORTING INFORMATION - (Continued)

Graduate Research Assistant	To be selected	Graduate student
Graduate Research Assistant	To be selected	Graduate student
Admin. Assistant-Secretary	To be selected	
Professional Programmer	To be selected	

2. Other Project Activity - D. W. Hendricks

   a. Supporting agency: National Science Foundation

   b. Grant No.

   c. Title: Interdisciplinary Engineering for Public Works Projects

   d. Effort: Eight months during period July 1, 1971 to September 30, 1972

   e. Estimated project cost: $134,400

   f. Project period: July 1, 1971 to September 30, 1972

Has this application been submitted elsewhere? No, nor is this planned.

3. Publications and References

   a. Publications by project personnel related to proposed work: D. W. Hendricks

      (1) D. W. Hendricks and J. M. Bagley, "Water Supply Augmentation by Reuse," Proceedings of the AWRA Conference on Water Balance in North America, Banff, June 1969.

      (2) D. W. Hendricks, N. P. Dixon, and R. S. Whaley, "System Economic Response to Water Quantity and Quality," Water Resources Bulletin, Journal of American Water Resources Assoc., Vol. 6, No. 4, pp. 682-694, August 1970.

      (3) N. P. Dixon and D. W. Hendricks, "Simulation of Spatial and Temporal Changes in Water Quality Within a Hydrologic Unit," Water Resources Bulletin, Journal of American Water Resources Assoc., Vol. 6, No. 4, pp. 483-497, August 1970.

(4) N. P. Dixon, D. W. Hendricks, A. L. Huber, and J. M. Bagley, "Developing a Hydro-Quality Simulation Model," Utah Water Research Lab Report PRW667-1, Logan, Utah, June 1970.

(5) A. Bruce Bishop and D. W. Hendricks, "Water Reuse Systems Analysis," Journal Sanitary Engineering Div., ASCE, Vol. 97, No. SA1, Proc. Paper 7898, February 1971.

(6) A. Bruce Bishop, D. W. Hendricks, and J. H. Milligan, "Assessment Analysis for Water Supply Alternatives," Water Resources Bulletin, Journal American Water Resources Assoc., Vol. 7, No. 3, June 1971.

(Plus about twelve additional titles).

Also relevant to the proposal are:

(7) D. W. Hendricks, "The Metabolism of Society - The Management of Wastes," unpublished Sigma Xi Lecture - Utah State University Chapter, November 1969.

b. Publications by Hubert J. Morel-Seytoux
(see following pages)

c. Publications and reports by others significantly related to proposed work
(see Appendix B)

Literature is cited in three places; (1) as references to document our narrative in the main text, (2) as publications of the project directors' and (3) as a bibliography located in Appendix B. The bibliography in Appendix B is included to indicate the trends and orientation in the literature regarding applications of system analysis to water quality problems. It is clear that the mathematical developments and socio-economic considerations have progressed rapidly from a theoretical viewpoint but have not been absorbed into practice.

SECTION II - PRIVILEGED COMMUNICATION

4. BIOGRAPHICAL SKETCHES

(Give the following information for EACH key staff member, beginning with the Principal Investigator. Use continuation pages and follow the same general format for each person.)

NAME	TITLE	BIRTHDAY (Mo., Day, Yr.)
David W. Hendricks	Associate Professor of Civil Engineering	9/10/31
PLACE OF BIRTH (City, State, Country)	**PRESENT NATIONALITY (If non-U.S. citizen, indicate visa status)**	**SEX**
Springfield, Missouri, U.S.A.	Social Security #549-34-2479	☒ Male ☐ Female

EDUCATION (Begin with baccalaureate training and include postdoctoral)

INSTITUTION AND LOCATION	DEGREE	YEAR CONFERRED
University of California, Berkeley (Civil Engineering)	B. S.	1954
Utah State University, Logan (Hydraulic and Irrig. Engin.)	M. S.	1960
University of Iowa, Iowa City (Sanitary Engineering -- minor in physical chemistry)	Ph. D.	1965
University of Wisconsin, Madison, Sept. 1964-March 1965		
Massachusetts Inst. of Technology, Summer Inst. in Systems Analysis, 1968		

HONORS

None

MAJOR RESEARCH INTEREST

1. Waste management and environmental quality
2. Physical chemistry of waste treatment

RELATIONSHIP TO PROPOSED PROJECT

Technical co-director for water quality systems analysis

RESEARCH AND/OR PROFESSIONAL EXPERIENCE (Start with present position; list ALL experience relevant to project.)

1. Assoc. Prof. of Civil Engineering, Civil Eng. Dept., Colorado State University August, 1970 - present.
2. Assoc. Prof., Assist. Prof. of Civil Eng., Utah Water Research Lab., July, 1965 - August, 1970.
   a. Teaching: (1) water chemistry, (2) unit operations in sanitary engineering (3) engineering systems analysis
   b. Research: Water quality
3. Graduate Student, University of Iowa, September 1961 - June 1965
   a. USPHS Terminal Doctoral Fellowship, May 1, 1964 - April 30, 1965
   b. Research Assist., May 1, 1963 - April 30, 1964
      Ecology of Actinomycetes in Natural Streams
   c. Academic Work: Major in sanitary engineering with some work in fluid mechanics and hydraulics and minor in physical chemistry
4. Instructor, Assist. Research Prof., Eng. Exp. Sta. and Civil Eng. Dept., Univ. of Idaho, Jan. 1958 - Sept. 1961.
   a. Teaching: (1) fluid mechanics, (2) hydraulics, (3) hydrology
   b. Research: Canal Seepage

Additional assignments:

1. Consultant, Eimco Corp., 1966 and 1967--research on waste treatment equipment design.
2. Consultant, Water Quality Associates, for Cornell, Howland, Hayes, Merryfield--on stream pollution, 1966 and 1967.

SECTION II - PRIVILEGED COMMUNICATION

5. BIOGRAPHICAL SKETCHES

(Give the following information for EACH key staff member, beginning with the Principal Investigator. Use continuation pages and follow the same general format for each person.)

NAME	TITLE	BIRTHDATE (Mo., Day, Yr.)
Hubert J. Morel-Seytoux	Associate Professor of Civil Engineering	
PLACE OF BIRTH (City, State, Country)	**PRESENT NATIONALITY (If non-U.S. citizen, indicate visa status)**	**SEX**
	U. S. Citizen Social Security 551-56-2420	☒ Male ☐ Female

EDUCATION (Begin with baccalaureate training and include postdoctoral)

INSTITUTION AND LOCATION	DEGREE	YEAR CONFERRED
Ecole Nationale des Ponts et Chaussee, Paris	M. S.	1956
Stanford University, Palo Alto, California	Ph. D.	1962
Doctoral Major: Hydraulics Doctoral Minor: Mathematics		

HONORS

MAJOR RESEARCH INTEREST

Multiphase flow in porous media
Stochastic hydrology
Applied mathematics, statistics
Systems analysis and computer simulations of complex technical problems

RELATIONSHIP TO PROPOSED PROJECT

Technical co-director for water quantity systems analysis

RESEARCH AND/OR PROFESSIONAL EXPERIENCE (Start with present position; list ALL experience relevant to project.)

1966 to present - Colorado State University, Department of Civil Engineering.

1962 to 1966 - Chevron Research Co., Reservoir Analysis and Applied Mathematics Section.

1960 to 1962 - Ecole de Guerre, Paris, Department of Military Operations Research.

PROJECTS - current

Hydrological aspects of Weather Modification
Systematic Treatment of the Problem of Infiltration
Selection of Test Variable for Minimal Time Detection of Basin Response to Natural and Induced Changes.

TEACHING - current

Foundations of Engineering Optimization (Spring 1970, Summer 1970, Winter 1971)
Mathematics of Saturated Flow in Porous Media (Spring 1970)
Water Quality Hydrology (Spring 1971)

6. Publications

Morel-Seytoux, H. J.: "Effects of Boundary Shape on Channel Seepage," Technical Report No. 7, November 1961, Department of Civil Engineering, Stanford University, 100 pages.

Morel-Seytoux, H. J.: "Flow Characteristics in a Doubly Periodic Pattern of Injection and Production Well Lines for a Mobility Ratio of 1," Technical Memorandum, California Research Corporation, May 20, 1963, 36 pages.

Jennings, H. Y. and Morel-Seytoux, H. J.: "Laboratory Tests. Hydraulic Transportation of Iron Ore," California Research Corporation, October 4, 1963, 61 pages, (Confidential).

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Dougherty, E. L. and Morel-Seytoux, H.J.: "Simulation of Moving Interfaces in Oil Reservoirs," in "Computers in the Mineral Industries," Part 2, Stanford University Press, 1964, pp. 845-880.

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Morel-Seytoux, H.J.: "A Study of Quasi-Linear Noncapillary Two-Phase Flow in Porous Media," Chevron Research Company, Research Report 900, September 23, 1966, 95 pages. (Restricted to Company Use).

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Morel-Seytoux, H.J.: "Yearly Report No. 1, August 21, 1967," Bureau of Reclamation Skywater Project 1967 Annual Report, January 1968, Volume 2, pp. 1-13.

Morel-Seytoux, H.J.: "Suitability of Basins to Weather Modification and Statistical Evaluation of Attainment," Final Report to the Bureau of Reclamation for FY 1966 and 1967, Hydrology Program, Colorado State University, Fort Collins, Colorado, July 1, 1968, Part 1, 62 pages. Part 2, 19 maps. Part 3, 118 pages. Part 4, 30 pages.

Morel-Seytoux, H.J.: "Yearly Report No. 2, August 30, 1969," Bureau of Reclamation Skywater Project 1968 Annual Report, January 1969, Volume 2, pp. 7-31.

Dumas, A.J. and Morel-Seytoux, H.J.: "Statistical Discrimination of Change in Daily Runoff,: Colorado State University Hydrology Paper No. 34, August 1969, 29 pages.

Morel-Seytoux, H.J.: "Introduction to Flow of Immiscible Liquids in Porous Media," Chapter XI in "Flow through Porous Media," R. de Wiest, editor, Academic Press, 1969, pp. 455-516.

Nakamichi, H. and Morel-Seytoux, H.J.: "Suitability of the Upper Colorado River Basin for Precipitation Management," Hydrology Paper No. 36, Colorado State University, October 1969, 62 pages.

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Morel-Seytoux, H.J.: "Yearly Report No. 1, August 31, 1969" Bureau of Reclamation Skywater Project 1969 Annual Report, March 1970, pp. 53-68.

Brustkern, R. L. and Morel-Seytoux, H.J.: "Analytical Treatment of Two-Phase Infiltration." A.S.C.E., Hydraulics Division, December 1970, pp. 2535-2548.

Publications - (Continued)

Phuc, Le Van and Morel-Seytoux, H.J.: "Effect of Airflow on Infiltration Rates," submitted for publication in the Proceedings of the Soil Science Society of America, being revised.

Phuc, Le Van and Morel-Seytoux, H.J.: "Computer Simulation of Capillary Hysteretic Cycles in Infiltration," submitted to S.S.S.A. for publication, being revised.

Nakamichi H. and Morel-Seytoux, H.J., "Runoff Grouping for Detection of Change in Runoff," Tour. of Irrigation and Drainage Division, ASCE, Vol. 97, No. IR2, June 1971, pp. 275-290.

APPENDIX A

DESCRIPTION OF STUDY AREA

Physical Description of Planning Area and Basin

The Basin Plan area will encompass the Poudre and Big Thompson Rivers from headwaters to their confluence with the South Platte River and the South Platte River in Weld County. The Regional Plan will encompass the Ft. Collins-Loveland-Greeley triangle. Figure A-1 shows the basin planning area and Figure A-2 shows the regional metropolitan planning area. The geographical diversity includes high value scenic and recreational reaches of the respective rivers and adjacent lands in the mountains, and on the plains, fast growing urban communities (3.8% per year), an extensive irrigated agriculture (over 240,000 acres), a massive feedlot industry (about 100, including the two largest in the US), industrial development (the most recent is 1800 employees), and need for upgrading currently polluted streams. Water related organizational entities include: over 32 irrigation companies, over 10 municipal water districts, exclusive of cities and towns, over 10 sewer districts, and three major cities, and many nearby towns. Unified water planning can explore all alternatives to exploit water reuse alternatives, economies of scale in treatment, and in supporting and implementing a realistic water quality plan commensurate with national and local social goals for the stream system. Table A-1 shows the existing sewage treatment facilities for the two counties.

Statement of Problem

Mountain Zones - The upper reaches of the Big Thompson and Poudre Rivers are both national and regional assets. These upper reaches are

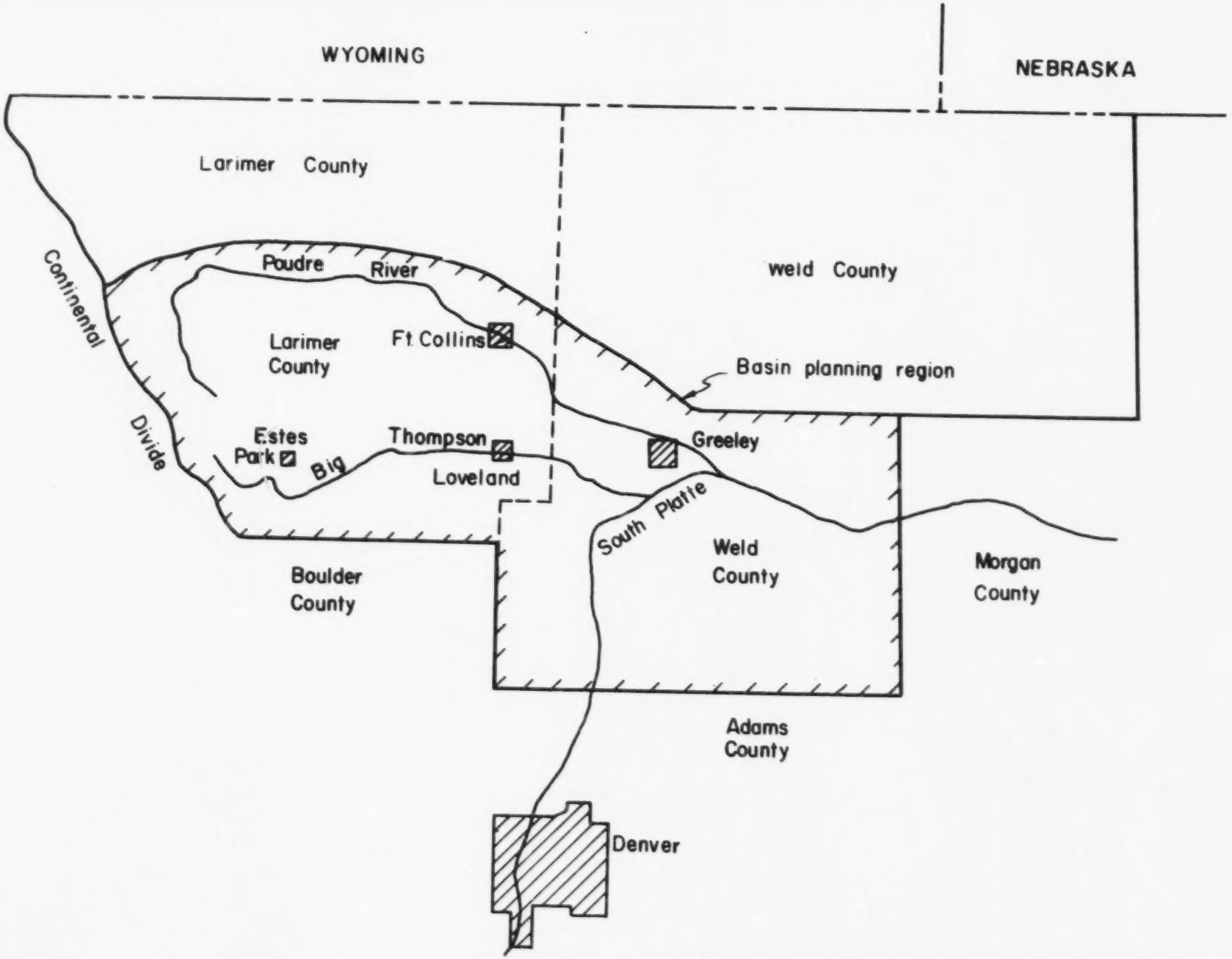

Figure A-1 – Planning region and basins – Larimer and Weld counties, Colorado.

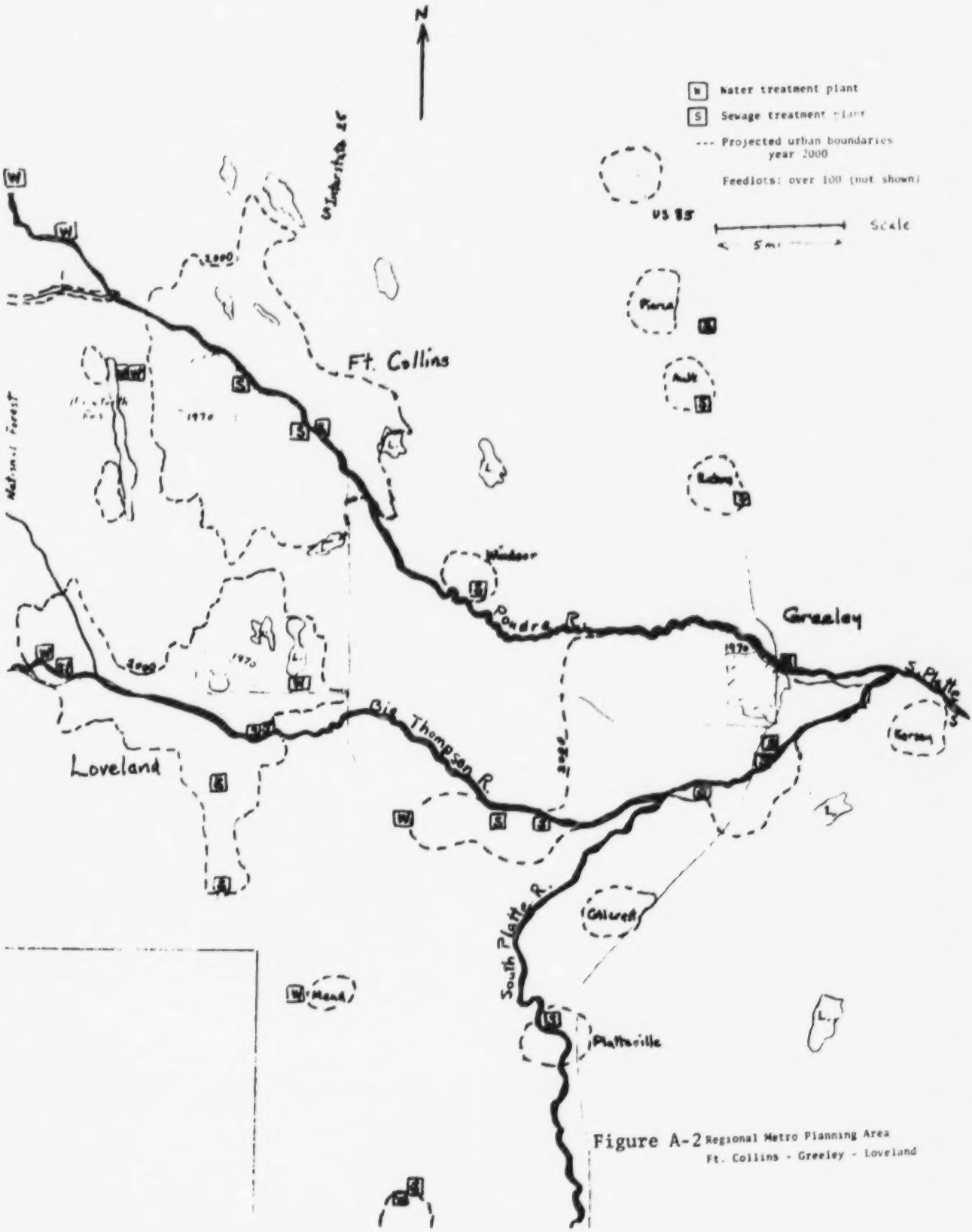

Figure A-2 Regional Metro Planning Area
Ft. Collins - Greeley - Loveland

Table A-1

SEWAGE SYSTEMS - LARIMER COUNTY - WELD COUNTY - 1970[1]

Community	Population	Taps	Discharge Thousands gpd	Effluent BOD mg/l	Discharge To	Type Treatment	Comments
Berthoud	1,700	713	360	13.20	Little Thompson	Trickling filters	Expansion proposed
Fort Collins	43,337	9,148	7,440				
Plant #1				10.60	Poudre River	Trickling filters	Near design capacity
Plant #2				16.66	Poudre River	Activated sludge	Near design capacity
Loveland	16,220	5,605	2,600	42.50	Big Thompson	Trickling filters	Near design capacity
Wellington	645	225	110	12.94	Boxelder Creek	Aerated lagoons	
Boxelder S.D.	1,800	419	250	33.76	Poudre River	Lagoon	Violating standards
Estes Park S.D.	9,800 (summer)	4,075 (summer)	520	5.20	Big Thompson	Activated sludge	
North College Sanitation Dist.	4,500	1,120	300	90.00	Poudre River	Trickling filters	Cease & desist issued
S. Ft. Collins Sanitation Dist.	1,500	381	200	18.80	Fossil Creek	Lagoons	Violating standards
Ault S.D.	828	325	60	50	Dry Creek	Imhoff and Trickling filter	
Dacono S.D.	363	112				Lagoon	
Eaton	1,389	560	140	8	Ditch	Extended aeration	
Erie S.D.	1,090	300	80	34	Ditch	Aerated lagoons	
Evans	2,570	600	250	40	S. Platte	Aerated lagoon	
Fort Lupton	2,489	785	200	37	S. Platte	Lagoons	
Gilcrest S.D.	401	120				Lagoon	Non-discharging
Greeley	38,902	9,614					Plan to build additional treatment facilities for packing house wastes
Plant #1			750	85	Poudre River	Trickling filter	
Plant #2			7,250	386	Poudre River	Activated sludge	
Hill & Park S.D.	400	130	20		S. Platte	Lagoon	
Hudson S.D.	513	210	50	8	S. Platte	Lagoon	
Johnstown	1,191	370	100	23	Little Thompson	Lagoon	
Keenesburg S.D.	437	190	40	57	Dry Ditch	Lagoon	
Kersey	467		40	140		Lagoon	Needs Aeration or more lagoon
LaSalle	1,227	400	100	18	S. Platte	Lagoons	
Mead S.D.	189	70	15		Intermittent Stream	Lagoon	
Milliken S.D.	710	180	70	2	Big Thompson	Extended Aeration	
Pierce S.D.	438	136				Lagoon	No discharge since built in 1970
Platteville	671	240	60	48	S. Platte	Lagoon	
Windsor	1,564	613	160		Poudre River	Aerated Lagoon	Under construction

[1]From Interior Water and Sewer Planning Report, Larimer-Weld Regional Planning Commission, April 1971.

more "value sensitive" to pollution effects than in the lower reaches; they are scenic, and are good trout fisheries, and serve as municipal water supply sources - as well as irrigation supplies. Presently, pollution problems are not evident despite the intensive summer activities adjacent to these streams. The city of Estes Park is the only incorporated municipality; the summer population increases to near 10,000. These upper reaches should be considered in the Basin Plan, even though Estes Park is the only waste input subject to control. A pollution control program would be difficult to implement if indeed necessary, because of the generally diffuse character of the activities. Because of the unique qualities of these mountain reaches, they should be included in the Basin Plan so that some institutional mechanism is available for planning and implementing pollution control if and when this becomes necessary.

Plains - As the Poudre and Big Thompson Rivers emerge from their mountain canyons they flow through cities and irrigated agricultural lands to join the South Platte River beyond Greeley. The latter stream recently has been upgraded to class A while the Poudre is classified as B_2, C, and D_1, and the Big Thompson is C and D_1. There is continued discussion regarding upgrading the Poudre River. Dissolved oxygen levels in this stream range from extremes of 12% saturation at night to 187% during the day - with large diurnal fluctuations (10). As the stream flows through Ft. Collins it is not suitable for higher forms of aquatic life; organic loadings increase as a result of several waste treatment plants discharging into the river; the river also becomes turbid and large amounts of plankton and filamentous bacteria are evident (10). During high water periods,

during spring runoff, these problems are less severe (9). Similar problems are evident in Weld County. These rivers are largely diverted during summer months for irrigation and municipal uses, which presents a dichotomy in logic if higher water quality standards are proposed. This question needs to be brought into better focus in an effort to assess alternatives for meeting desired social objectives for in-stream uses and the corresponding "opportunity costs". Both the supply side and the waste side need to be considered in any comprehensive planning to realize a "cost-effective" solution which is compatible with the full spectrum of water use objectives - including the maintenance of water quality for in-stream uses and for further diversions. The effects of diffuse inputs from irrigation return flows and stochastic inputs resulting from feedlot runoff must be considered in comprehensive basin planning. It is well established that salinity levels increase in the downstream direction for the streams in Larimer and Weld counties - presumably due to irrigation return flow. Conductivity measurements show increases from 50 micromhos/cm in the canyons to over 2000 near Greeley (10, 28). The effects of feedlot runoff has never been properly assessed; but the detrimental potential is appreciable.

Of course one of the major causes of problems is the rapid growth of the region which is causing stress on both the supply and waste sides of water use. Projections for water use are shown in Figure A-3. It is seen that by the year 2000 a deficit will occur.

Some of the institutional problems involve diffuse ownership of water among 30 to 50 municipal and irrigation entities; also responsibility for waste water collection and treatment is diffused in the urban areas among several sanitary districts in each urban area. The

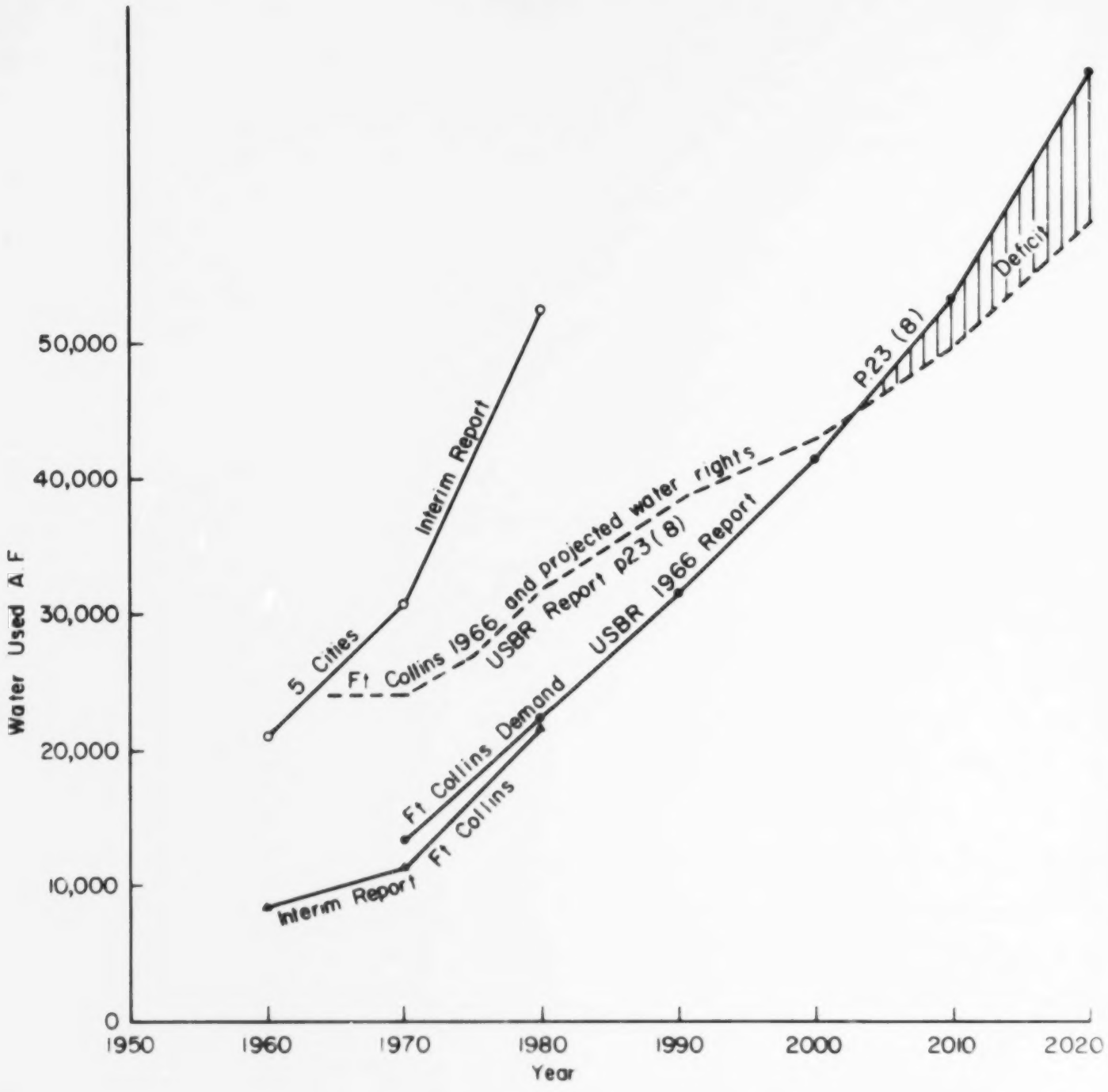

Figure A-3 - Projected municipal demand and water supply for Ft Collins with comparison for 5 city total

new Larimer-Weld Regional Commission is a potentially effective vehicle for coordinated planning in all activity spheres, thus providing the necessary administration and interfacing between this proposed activity and land use planning and the development of regional social objectives for the use of common property resources. Should regional treatment facilities of any type be recommended as a result of this study, the Commission is a vital administrative unit in approving any recommended charge structure, and developing a workable plan.

Status of Basin Planning

Several studies have been undertaken in the past, upon which, this project will build. These activities have included:

1) A US Bureau of Reclamation Study, Concluding Report, July 1966; Region 7, Denver, on the feasibility of Idylwilde Dam. This report contains hydrologic information for the Poudre River and municipal and industrial water use data for Ft. Collins and Greeley.

2) Area Sewerage Treatment Facilities Development Plan for Larimer County, March 19, 1969, Larimer County Health Dept. This is a comprehensive sewage plan which links up the Ft. Collins urban area into a unified system, and does the same for Loveland; this study will aid the proposed one by delineating the subregion linkages - allowing the current study to concentrate on inter-city transport costs.

3) Comprehensive Survey of the Cache La Poudre River by G. Misbach, Colorado State Health Department, 1970. This was a water quality survey of the Poudre River from Ft. Collins to Greeley done in May and in September 1970.

4) The Larimer County Health Department under the supervision of Mr. Douglas Wigle has given continued extensive sampling surveillance to the waters of the area.

5) Interim Water and Sewer Planning, Larimer-Weld Regional Planning Commission, April 1971. This report is an inventory of data, specified by EPA as per Title 18, Chapter 5, Part 601 of the Water Quality Act of 1965. This report contains population projections and inventories all water and sewage treatment facilities, and shows locations of industries, feedlots, etc.

6) The Environmental Protection Agency is planning a comprehensive survey of the water quality conditions in the South Platte Basin to include the Poudre and Big Thompson subbasins, as a follow-up of the 1966 enforcement conference. This effort could be highly valuable for the proposed study.

These studies will, of course, be utilized in the proposed basin planning effort.

APPENDIX B

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APPENDIX C

Authorization to Develop Certified Regional and Basin Plans

Authority

Accomplishment of this project will result in satisfaction of requirements for comprehensive water pollution control planning as described under section 3 (C) PL 84-660 as ammended and delineated by the 1971 Guidelines for Water Quality Management Planning. Certified basin and regional plans are specific objectives of the proposed project. The basin plan will encompass the Poudre River, the Big Thompson River and the South Platte River as shown in Figure A-1. The regional plan will encompass the Ft. Collins-Greeley-Loveland metropolitan triangle, including towns in the area wishing to be included.

Authority to develop and implement the certified plan is vested in the Larimer-Weld Regional Planning Commission, as designated by Govenor Love in a letter of April 27, 1971; this letter follows.

Cooperation and Support-Historical Resume

This project was conceived in September 1970 by the project co-directors, H.J. Morel-Seytoux and D.W. Hendricks as a research project to articulate systems analysis planning principles for regional wastewater treatment and water reuse and water quality maintenance of streams, using a selected study area. In this context the plan developed would have had no assurance of much more than mathematical relevance.

Discussions in Denver in early November with Mr. Dave Clark and Mr. Chris Timm indicated interest in this systems analysis approach to

regional water and wastewater planning; however, these approaches as academic exercises are reasonably abundant and the current need is to implement such concepts. Thus it was concluded that E.P.A. in general did not encourage research strictly in a university environment but favored cooperation of university staff with local government so that the research stood a fair chance to be implemented. (We should emphasize here that this discussion was not construed then or now as a committment by E.P.A.; expressions of interest and some help and guidance in developing grant applications is common practice by some government agencies).

Later in November Mr. Doug Wigle, Director of the Larimer County Health Dept. was contacted. After several meetings in December, January, and February the project crystallized better as it met needs within Larimer County. It became also apparent how the proposed project would interface with other activities. In fact Mr. Wigle was actively thinking along the lines of reuse and a regional waste management planning. During this period Mr. William Manuel, Larimer County Commissioner and Mr. Dwight Whitney, Larimer County Planner became aquainted with the project. Since the date of their first meeting, December 15, 1970, to date June 1971, (that is for the past six months) it can be said that they have worked hand in hand for the success of this project. As a result of their efforts a first draft of a grant application was sent to the Denver E.P.A. office in mid January 1971 for their information and comments. Originally a more limited study was conceived, restricted geographically and politically to a fraction of Larimer County. However, both from a logical point of view and because of the interest expressed by Weld County and the cities in the two counties

the project could not be true to itself without growing into a real regional study. In fact as the January 1971 Guidelines became available to the writers (in March 1971) it was soon evident that the project goals virtually coincided with the Guidelines, which thoroughly enumerate considerations important in regional and basin planning. The authors were aware of the 3 C planning grant avenue of funding but after careful consideration it was felt that the demonstration grant route was more appropriate to the innovative nature of the project.

During the months of March, April and May a number of additional meetings were arranged through the offices of Mr. Manuel, Mr. Whitney, Mr. Wigle, Mr. Frank Rozich, Dr. Norman Evans, Mr. Pat Godsil, and Mr. Dave Clark, with the Water Pollution Control Division, Colorado State Health Dept., the Environmental Protection Agency, the Larimer and Weld County Commisiioners, the Loveland, Ft. Collins, Greeley city officials, the Larimer-Weld Regional Commission Advisory Committee, and Mr. J.R. Barkley of the Northern Colorado Water Conservancy District.

As a result of these developed liasons the project has an excellent prognosis for being accepted and implemented with a considerable degree of enthusiasm. This collective support, which exists we feel in both depth and breadth, is a most vital part of the proposed project. The organizational momentum developed can be preserved and enhanced further through the organizational structure and the orientation of the project. The proposed project must be palatable to all participating political entities if it is to be workable. Considerable optimism is justified at this time that the project can result in an enlightened and an advanced contribution to the specific area studied and to the state of the art capability in systems planning.

Evidence of Support

Letters which follow are intended to document the authorization and support needed to execute this grant application.

1. Authorization by the Larimer-Weld Regional Planning Commission to file this application.

2. Designation of the Larimer-Weld Regional Planning Commission as the responsible planning agency by Governor Love.

3. Resolution by Larimer County to create the Larimer-Weld Regional Planning Commission.

4. Resolution to appoint members to the Larimer-Weld Regional Planning Commission.

5. Memorandum dated April 22 explaining grant application draft from W.C. Manuel, D.W. Hendricks, H.J. Morel-Seytoux.

6. Copy of minutes, Greeley City Council, dated May 4.

7. Resolution Weld County Commissioners, dated May 5.

Attachment A: Committment for in-kind services if needed for grant application.

8. Copy of minutes, City of Windsor, dated May 4.

9. Recommendation for grant approval, Larimer County Planning Commission, dated May 18.

10. Resolution from Larimer-Weld County Regional Commission Advisory Board on behalf of grant application, dated May 18.

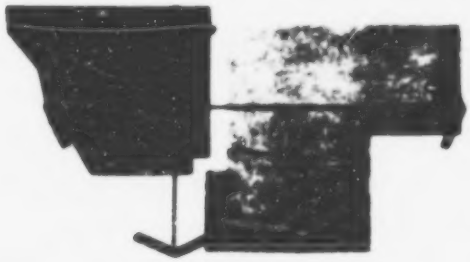
11. Letter indicating interest and desire for cooperation from Mr. J.R. Barkley, Secretary-Manager, Northern Colorado Water Conservancy District, dated May 25.

12. Letter of approval for grant application, Board of County Commissioners, Larimer County, dated May 27.

13. Letter of Support and Interest, City of Fort Collins, dated June 18.

14. Letter of endorsement, Water Pollution Control Division, Colorado State Health Dept.

15. Letter expressing full cooperation by Office of Contracts and Grants, C.S.U. with the special format of the grant.



larimer-weld regional planning commission

June 8, 1971

State Department of Health
Water Pollution Control Commission
4210 East Eleventh Avenue
Denver, Colorado 80220

Gentlemen:

The Larimer-Weld Regional Planning Commission unanimously recommends that the Water Pollution Control Commission accept this application for Research, Development, and Demonstration Grant as submitted by Mr. William Manuel, Dr. David W. Hendricks, and Dr. Hubert J. Morel-Seytoux.

Sincerely,

Dwight Whitney
Larimer-Weld Regional Planning Commission

DW/kl

cc: Weld County

POST OFFICE BOX 2137 / FORT COLLINS, COLORADO 80521 / 484-1303
SERVICE BUILDING / GREELEY, COLORADO 80631 / 353-6217

GOVERNOR'S OFFICE
DENVER, COLORADO

April 27, 1971

Mr. David Dominick
Acting Commissioner
Water Quality Office
Environmental Protection Agency
Washington, D. C. 20242

Dear Mr. Dominick:

I hereby designate the Larimer-Weld County Regional Planning Commission as the agency responsible for planning and coordination of comprehensive basin water pollution control plans in that portion of the South Platte River Basin that lies within the jurisdiction of the planning agency.

This action is a requirement before Federal matching funds can be sought through the Office of Water Quality--Environmental Protection Agency 3(c) program in comprehensive basin planning. This designation is made with the provision that the extent of the duties and responsibilities of the planning agency in water pollution control planning shall be determined by the Water Pollution Control Commission, and is, therefore, subject to approval by the Commission.

COPY

Please do not hesitate to contact me if any questions arise in regard to this designation.

Sincerely,

John A. Love

JAL:te

cc: Larimer-Weld County Regional Planning Commission
cc: Colo. Dept. of Health Water Pollution Control Commission

Reproduced from best available copy.

A RESOLUTION BY THE COUNTY OF LARIMER, COLORADO, TO CREATE THE LARIMER-WELD REGIONAL PLANNING COMMISSION

WHEREAS, it is the desire of the Board of County Commissioners of Larimer County, Colorado, to cooperate with the Board of County Commissioners of Weld County, Colorado, in planning and zoning matters having a joint interest to both of said counties;

WHEREAS, such matters may include the following:

The general location, character, and extent of streets or roads, viaducts, bridges, parkways, playgrounds, forests, reservations, parks, airports, and other public ways, grounds, places and spaces; the general location and extent of public utilities and terminals, whether publicly or privately owned, for water, light, power, sanitation, transportation, communication, heat, and other purposes; to acceptance, widening, removal, extension, relocation, narrowing, vacation, abandonment, or change of use of any of the foregoing public ways, grounds, places, spaces, buildings, properties, utilities or terminals; the general character, location, and extent of community centers, town sites, housing developments, whether public or private, and urban conservation or redevelopment areas; the general location and extent of forest, agricultural areas, flood control areas, and open development areas for purposes of conservation, food and water supply, sanitary and drainage facilities, flood control, or the protection of urban development; and a land classification and utilization program;

WHEREAS, the area of immediate interest to said counties is the area along the North-South, Larimer-Weld county line between Fort Collins and Loveland, but the Boards of County Commissioners of

may from time to time involve other areas within the counties;

NOW, THEREFORE, BE IT RESOLVED, That there be, and there hereby is, created, pursuant to authority granted in Chapter 106, Article 2, of the 1963 Colorado Revised Statutes, as amended, a regional planning commission to be known as the Larimer-Weld Regional Planning Commission and having as its area of jurisdiction the unincorporated territory of both Larimer County and Weld County in the State of Colorado;

BE IT FURTHER RESOLVED That the Rules of Association for said regional planning commission, attached hereto and made a part hereof, be, and they hereby are, adopted.

DATED at Fort Collins, Colorado, this ____ day of _____, 1969.

BOARD OF COUNTY COMMISSIONERS
OF THE COUNTY OF LARIMER AND
STATE OF COLORADO

By _____
William C. Kinsel, Chairman

(SEAL)

ATTEST:

_____
Phyllis D. Taylor, [illegible] and
Acting Clerk of said Board

RESOLUTION

RE: APPOINTMENT OF MEMBERS FROM WELD COUNTY TO THE LARIMER-WELD REGIONAL PLANNING COMMISSION.

WHEREAS, pursuant to Colorado Revised Statutes '63, 10-2-4, the Larimer-Weld Regional Planning Commission has been created comprising of Larimer and Weld Counties, and

WHEREAS, the rules of association of the Larimer-Weld Regional Planning Commission provide for the appointment of a twelve (12) member Board, to run and manage said Regional Planning Commission, and

WHEREAS, Weld County is entitled to six (6) members on said Commission who will serve staggered terms as provided in the rules of association of said Regional Planning Commission, and

WHEREAS, the Board of County Commissioners of Weld County, Colorado, is authorized to appoint Weld County representatives to said Regional Planning Commission.

NOW, THEREFORE, BE IT RESOLVED, by the Board of County Commissioners of Weld County, Colorado, that the four (4) regular members of the Weld County Planning Commission, one (1) alternate member of said Planning Commission, and the Chairman of the Board of the Weld County Commissioners be, and they hereby are, appointed as the representatives from Weld County, to serve on the Larimer-Weld Regional Planning Commission pursuant to the rules and regulations of said Regional Planning Commission, as may be adopted.

The above and foregoing Resolution was, on motion duly made and seconded, adopted by the following vote, on the 17th day of September, 1969.

AYES:

BOARD OF COUNTY COMMISSIONERS
WELD COUNTY, COLORADO

ATTEST:

CLERK OF THE BOARD

APPROVED AS TO FORM:

COUNTY ATTORNEY

MEMO

Date: April 22, 1971

To: Representatives of Larimer - Weld City and County Governments, Colorado Water Pollution Control Commission, and Environmental Protection Agency

From: William C. Manuel, David W. Hendricks, H. J. Morel-Seytoux

Subject: Water quality planning grant applications to EPA

Remarks:

The enclosed grant applications outline methods for developing:

(1) a comprehensive river basin pollution control program for the Cache La Poudre, Big Thompson, and South Platte Rivers, in Larimer and Weld Counties.

(2) a regional plan for liquid waste management for the Ft. Collins - Loveland - Greeley urban triangle.

Part I is the "3c" application for comprehensive river basin planning and Part II is a "demonstration grant" application. Part I is the framework for the total problem. This includes consideration of upper basin problems relating to activities in the mountain canyons. Also in Part I, it is necessary to establish the administrative mechanisms for implementing regional programs and plans. This includes recommending user fees, financing recommended construction, and enabling legislation as necessary, and a suitable organization structure for continuing implementation and updating of plans.

Part II outlines the procedures for modeling the river basin and regional water and waste systems, with special reference to the lower reaches (ie beyond the canyons). The regional water-waste plan will come from these models; they will be developed for usefulness beyond the period of this project.

We should emphasize that Part I is preliminary; not only is the budget yet undefined, but an explicit work plan should be developed to delineate the extent to which plans should be developed for the upper reaches.

Your comments and criticisms are solicited. We will discuss budgets, objectives, and scope more fully with representatives of each community and hopefully try to absorb these thoughts into a final draft for submission to EPA; we are striving to have this ready in early May.

B. Councilman Wells submitted copies of a memo from Commissioner William C. Manuel, Dr. David W. Hendricks and Dr. H. J. Morel-Seytoux to Representatives of Larimer-Weld City and County Governments, Colorado Water Pollution Control Commission, and Environmental Protection Agency, concerning water quality planning grant applications to E.P.A. He stated that a letter was needed for authorization from the Council designating the Larimer-Weld Regional Planning Commission as the regional planning agency representing the City of Greeley's interests in the development of a basin-wide pollution control plan.

Motion was made by Councilman Sodman and seconded by Councilman Rucker to authorize the Larimer-Weld Regional Planning Commission to use Greeley's expenditures for in-kind matching money providing it does not conflict with any City of Greeley application for federal aid project. Motion carried unanimously.

There being no further business, the meeting was adjourned.

_____
MAYOR

BY: _____
CITY CLERK

I, Lola Bowman, City Clerk of the City of Greeley, do hereby certify that the above is a true and exact copy of the last page of the Minutes of City Council meeting, May 4, 1971.

Lola Bowman
City Clerk

RE: LARIMER-WELD REGIONAL WATER-WASTE POLLUTION CONTROL PROGRAM.

WHEREAS, it is apparent to the Board of County Commissioners, Weld County, Colorado, that there is an urgent need for a comprehensive river basin water pollution and liquid waste control program in the Cache la Poudre, The Big Thompson and South Platte River basins in Larimer County and in Weld County, and

NOW, THEREFORE, BE IT RESOLVED, that the Board of County Commissioners, Weld County, Colorado, does strongly recommend and support the investigation, evaluation and development of a comprehensive program for the Larimer-Weld Regional Sewer and Water Study and for the implementation of the necessary plans and programs in connection therewith.

BE IT FURTHER RESOLVED that the Board strongly supports the action of the Larimer-Weld Regional Planning Commission in its application for federal funds to effect such regional water-waste program in Larimer and Weld Counties.

The above and foregoing Resolution was, on motion duly made and seconded, adopted by the following vote on the 5th day of May, 1971.

BOARD OF COUNTY COMMISSIONERS
WELD COUNTY, COLORADO

ATTEST:

Clerk of the Board

By: Deputy County Clerk

APPROVED AS TO FORM

GLENN K. BILLINGS
CHAIRMAN
RT. 2 BOX 167 GREELEY COLO

HAROLD W. ANDERSON
CHAIRMAN PRO TEM
RT. 1 JOHNSTOWN COLO

MARSHALL H. ANDERSON
MEMBER
2612 8TH AVE GREELEY COLO

WELD COUNTY
COLORADO

OFFICE OF
BOARD OF COUNTY COMMISSIONERS

GREELEY, COLO.

PHONE (303) 353-2212
EXT 21, 22 AND 23

ATTACHMENT A

WELD COUNTY ---------- IN KIND SERVICE

NAME	POSITION	ANNUAL SALARY	TIME ON PROJECT % OF HRS.	COST
Burman Lorenson	Weld County Planner	$13,500	25%	$ 3,375.00
Byron Ewing	Weld County Engineer	$10,000	5%	$ 500.00
Glenn Paul	Weld County Chief Sanitarian	$12,570	25%	$ 3,144.00
Un-assigned	Weld County Sanitarian	$ 8,688	75%	$ 6,516.00
			TOTAL	$13,535.00

Marshall H. Anderson, Chairman

Glenn K. Billings

Harry S. Ashley

The Windsor Planning Commission met May 4, 1971 at 7:30. Members present were Chairman Anderson, Ashley, Erbes, Miller, McDonald, Ehrlich; advisory members present were Medina, Schauerman; also Planner Scholl and Secretary Myrna Margheim.

The minutes of the April 7 meeting were read and approved. Also the minutes of a special meeting of April 16 were read and approved.

Mrs. Ralph Hickman came to discuss what is necessary to extend the sewer on her property. She was advised to get an engineer to draw her development plans and sizing of sewer lines.

Joe Simmons gave his final report in regards to the completion of his contract with the state. He stated the Planning Commission would be receiving copies of his report. Miller moved we accept the report presented by him, Erbes seconded. The motion was carried unanimously.

Next on the agenda was Daniel Ponton who was asking for a general feeling of the Planning Commission of his development. Preliminary plans for homes, town houses, motel, restaurant and general commercial use were shown. Anderson stated generally the Commission is pleased with these plans.

Tom Richardson, a representative of Foster-Schott presented a review of the proposed subdivision. The Commission stated they would not change their views of this subdivision. Scholl suggested we write another letter to the Weld County Planning Commission explaining that our feelings have not changed.

McDonald made a motion and Miller seconded the motion to re-elect the same officers of the previous year. Motion carried unanimously.

Ashley asked for the backing of Windsor to accept the Water Quality Planning Grant applications to Environmental Protection Agency. Miller made a motion and Ehrlich seconded the motion that we approve and recommend this to the Town Board. Motion carried unanimously.

Meeting adjourned 10:00.

Myrna Margheim

Respectfully Submitted
Myrna Margheim, Secretary

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LARIMER COUNTY PLANNING COMMISSION

FORT COLLINS, COLORADO 80521

PHONE 484 1303

P O BOX 2137

May 18, 1971

Board of County Commissioners
Larimer County Courthouse
200 West Oak
Fort Collins, Colorado

Gentlemen:

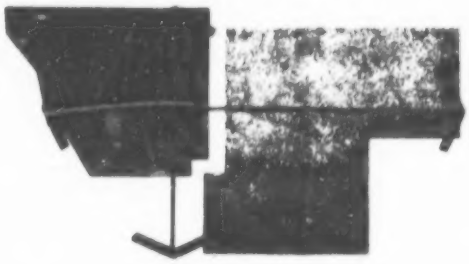
The Larimer County Planning Commission unanimously recommends that the Board of County Commissioners approve Part I grant application, Comprehensive Water Pollution Control Planning (under Section 3-C Pl 84-660 as amended) and Part II application for Research, Development, and Demonstration Grant as submitted by Dr. David W. Hendricks and Dr. Hubert J. Morel-Seytoux.

Sincerely,

Edwin N. Hanson

Edwin N. Hanson
Chairman

ENH/kwl



larimer-weld regional planning commission

May 18, 1971

Regional Director
Environmental Protection Agency
Region 8
Federal Office Building
19th and Stout Streets
Denver, Colorado 80202

Dear Sir:

From the minutes of the Advisory Board meeting of the Larimer-Weld Regional Planning Commission, May 3, 1971, 8:00 p.m., Farm Fare Restaurant, Lucerne: "Edwin Hanson made the motion that Dwight Whitney be instructed to draft a Resolution, with our approval, to endorse this request. John Connor seconded. Discussion followed and motion was carried."

This Resolution is as follows:

The Advisory Board of the Larimer-Weld Regional Planning Commission unanimously recommends that the Policy Board of the Larimer-Weld Regional Planning Commission approve Part I grant application, Comprehensive Water Pollution Control Planning (under Section 3-c Pl 84-660 as amended) and Part II application for Research, Development, and Demonstration Grant as submitted by Dr. David W. Hendricks and Dr. Hubert J. Morel-Seytoux.

Sincerely,

Thomas C. Bein

Thomas C. Bein
Chairman, Advisory Board

TCB/kwl

DIRECTORS

BOULDER COUNTY
C. V. HALLENBECK JR.
JOHN P. MURPHY
MILTON H. NELSON

LARIMER COUNTY
GORDON C. DYEKMAN
CLYDE E. MOFFITT
JOHN R. MOORE

WELD COUNTY
W. D. FARR
WILLIAM E. BOHLENDER
J. BEN NIX

WASHINGTON AND MORGAN COUNTIES
R. J. LAMBORN

LOGAN COUNTY
H. N. VANDEMOER

SEDGWICK COUNTY
KIYOSHI OTSUKA

EMERITUS DIRECTOR
ED F. MUNROE

NORTHERN COLORADO WATER CONSERVANCY DISTRICT

1250 NORTH WILSON AVENUE
(1 MILE WEST OF LAKE LOVELAND ON HIGHWAY 34—1 BLOCK SOUTH)
P. O. BOX 679 303-667-2437
LOVELAND COLORADO
80537

OFFICERS

J. BEN NIX, PRESIDENT
CLYDE E. MOFFITT, VICE-PRES.
J. R. BARKLEY, SECRETARY
J. C. NELSON, TREASURER

STAFF

J. R. BARKLEY, MANAGER
EARL F. PHIPPS, ASSISTANT MANAGER
DENNIS E. WALKER, O & M SUPERINTENDENT
J. C. NELSON, CONTRACTS ADMINISTRATOR
DAVIS, GRAHAM & STUBBS, LEGAL COUNSEL
PRINCIPAL COUNSEL
JOHN M. SAYRE
AMERICAN NATIONAL BANK BUILDING
DENVER, COLORADO 80202

May 25, 1971

Larimer-Weld Regional Planning Commission
% Wm. C. Manuel, Commissioner
Larimer County Court House
Fort Collins, Colorado 80521

Dear Mr. Manuel:

The opportunity to visit with you and Messrs. Hendricks and Morel-Seytoux on May 19 was much appreciated.

As I noted in our conversation, this District and its Board of Directors are fully aware of need for coordination between public entities in the planning required for optimum utilization of limited water resources in a dynamically growing area. I indicated, further, that we would soon have a member of our staff assigned to keep in touch with and continuously advise us of the planning progress and desires of the several counties, municipalities, and other local governments within our District area.

In the process of communication with the various planning groups, we will be glad to supply such input of physical or procedural data as may be useful if the planning groups so desire.

I assure you that we will appreciate the opportunity for discussion and review of any of the planning aspects related to water supply uses or water pollution controls.

Sincerely yours,

J. R. Barkley

Secretary-Manager

JRB:jm

LARIMER COUNTY PLANNING COMMISSION

FORT COLLINS. COLORADO 80521

PHONE 484-1303 P.O. BOX 2137

May 27, 1971

Environmental Protection Agency
Region 8
Federal Office Building
19th & Stout Streets
Denver, Colorado 80202

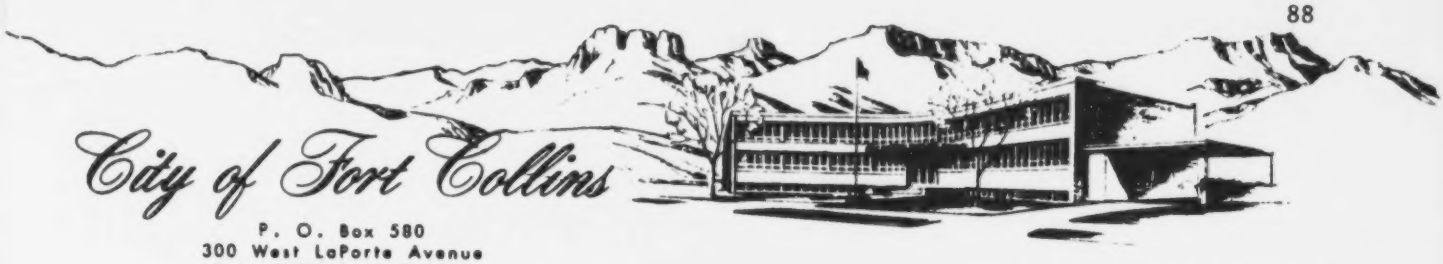
Gentlemen:

The Board of County Commissioners unanimously approve Part I grant application, Comprehensive Water Pollution Control Planning (under Section 3-C Pl 84-660 as amended) and Part II application for Research, Development, and Demonstration Grant as submitted by Dr. David W. Hendricks and Dr. Hubert J. Morel-Seytoux.

Sincerely,

Warren Wolaver

Warren Wolaver, Chairman
Board of County Commissioners



City of Fort Collins
P. O. Box 580
300 West LaPorte Avenue
Fort Collins, Colorado
80521

Telephone 303 484-4220

June 18, 1971

Larimer-Weld Regional Planning Commission
P. O. Box 2137
Fort Collins, Colorado 80521

Gentlemen:

The City of Fort Collins has recently been advised that a grant application has been submitted for a comprehensive River Basin Pollution Control Program Study, and a regional plan for Liquid Waste Management Study.

The City of Fort Collins is very much interested in the work to be accomplished by this project, and will cooperate with the principals in this study.

Respectfully yours,

Tom Coffey
City Manager

CL/lms

June 9, 1971

Office of Research and Development
U. S. Environmental Protection Agency
Washington, D. C. 20242

Re: Larimer-Weld Regional Planning Commission Demonstration Grant.

Gentlemen:

This will express support of the Colorado Water Pollution Control Commission to a demonstration grant application submitted by the Larimer-Weld Counties Planning Commission.

We have been actively involved in discussions leading to this application and feel the demonstration will provide a model regional sewage disposal plan for the western United States. It will evaluate alternatives for total water resource management, which is particularly important for waste water plans in the semi-arid west.

Since we feel that such a project is a vital need in this part of the nation, your prompt consideration and expediting of this request would be greatly appreciated.

Sincerely yours,

Frank J. Kozich

Frank J. Kozich, P.E.
Technical Secretary

FJR:bls

cc: Larimer-Weld Regional Planning Commission
Dr. Norman Evans
Professor D. Hendricks

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COLORADO STATE UNIVERSITY

FORT COLLINS, COLORADO 80521

OFFICE OF CONTRACTS AND GRANTS ADMINISTRATION

June 21, 1971

Environmental Protection Agency
Water Quality Office
Washington, D. C.

Attn: Dr. Roger Don Shull
Environmental Engineering
Pollution Control Analysis Branch
Division of Applied Science and Technology
Environmental Protection Agency
Washington, D. C. 20242

Gentlemen:

Colorado State University is willing to provide support for the proposed demonstration grant entitled "Regional Water Quality - Quantity Systems Analysis" submitted June 9, 1971 by the Larimer-Weld Regional Planning Commission.

The University is looking forward to a cooperative effort with the Commission in this study. If this office can be of any assistance in negotiating an agreement for the proposed demonstration grant, please feel free to call on us.

Sincerely yours,

James F. Brown

James F. Brown
Contracts & Grants
Administrator